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ABSTRACT

This issue is devoted to first language acquisition. It includes twelve papers concerning: the acquisition of liquids ("l" and "r"); creative errors in the written syntax of deaf children; theoretical and methodological problems in the acquisition of phonology, illustrated from Greek and English: the basis of articulation; the philosophy of science; and vowel nasalization. (Author/DD)

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WORKING PAPERS IN LINGUISTICS NO. 15

By

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Introduction

This issue of Working Papers is very largely devoted to first language acquisition. The first two papers present the full and unabridged version of Mary Edwards' master's thesis (June 1971) on the acquisition of liquids. and part of Jonnie Geis' work on creative errors in the (written) syntax of deaf children.

My own writings over the past two years, most of which are presented here, cover theoretical and methodological problems in the acquisition of phonology, illustrated from Greek (in collaboration with Angeliki Malikouti-Drachman) and from English, as well as a tentative revival of the classical notion Basis of Articulation and a single primitive foray into the philosophy of science (On the Interpretation of Primes). Looking back, I sense a certain development or at least continuity of treatment; I have thus ordered these papers chronologically.

Last, though only so because it breaks away from the main theme of this collection, is Larry Schourup's master's thesis (June 1972) on Vowel Nasalization.

Gaberell Drachman

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The Acquisition of Liquids

Mary Louise Edwards

1. Introduction

1.1. Purpose and Hypotheses

This thesis concerns the acquisition of liquids (l and r) by a number of children. The purpose of the investigation was to go beyond the surface substitutions to discover the phonological processes which would account for these substitutions and all the intermediate steps in the acquisition of the sounds involved.

The hypotheses were 1) that there are a few basic processes taking place in children's acquisition of liquids, 2) that acquisition can be accounted for by a model (proposed by David Stampe) which says that these processes are innate and are gradually limited and suppressed in acquisition, 3) that the changes taking place in the speech of children speaking other languages (French and German in this case) should vary according to the types of liquids found in these languages, and 4) that if the processes are phonetically plausible, they will be operating in languages of the world, and thus, evidence for them should be found in historical or dialectal change.

1.2. Methods

The data for the first four children was collected in 1968-70, and was gathered at regular interviews at the homes of the children. The interviews were approximately two hours long and took place two or three times a month. A few tape recordings were made, but most of the data were written in phonetic transcription as spoken by the child. The interviews were "free" in that no real attempt was made to get the children to talk. Usually I simply listened as the children were playing and transcribed their utterances. Sometimes I had them look at picture books with me and tell me the names of objects. Imitated forms are not included. Data for Emily Salus come from her father, and data for Jennifer Stampe come from David Stampe. The data for Joan Velten, Hildegard Leopold, and Edmond and Charles Grégoire come from the books or articles by the fathers of these children.

For each of these children all the words which should have contained liquids were collected and organized according to the

position of the liquids in the words. Then I tried to find the regularities and substitutions, and ultimately the underlying processes. This was done for the English-speaking children first. Then I analyzed the data for the French and German children to find out what underlying processes were operative in their speech. I expected to find that as the types of liquids varied, the subsequent substitutions (and thus the forms of underlying processes) would vary also.

Last, I looked through some books on language families and phonetic change for evidence of the same basic processes in historical or dialectal change. This was not intended to be an exhaustive search, but rather a random sampling. If my processes were phonetically plausible and natural, I assumed that they would be operative in some adult languages, as evidenced by phonetic change.

1.3. Model

This study differs from most concerning acquisition. First, it differs from the traditional studies which consist of vocabulary lists and atomistic listing of substitutions. These are patterned after Neogrammarian grammars. For such studies (e.g. Leopold 1939) each word is given in phonetic transcription, and the words are listed in alphabetical order along with the dates at which they appeared. This survey of word acquisition is very detailed and inclusive, but no attempt is made to generalize and integrate the data. In fact, Leopold states that it is too early to attempt generalizations, and thus he limits himself to the task of recording. He does tabulate the child's representation of standard sounds and gives some "rules" of sound substitution, but these rules are only superficial substitutions and changes (such as assimilation). There is no attempt to analyze substitutions like z → š into their constituent processes, in this case devoicing and palatalization. In spite of the detail of such studies as Leopold's, they require reanalysis because they do not connect parallel phenomena and do not reveal generalizations.

Second, my study differs from those inspired by Roman Jakobson. These studies usually consist of a statement of the child's successive "phoneme inventories." According to Jakobson (1968), the child's task is to master the system of phonemic oppositions. The principle in operation is that of "maximal contrast." The first opposition is a maximally open phoneme, e.g. /a/ versus a maximally closed one, e.g. /p/. Then the first consonantal opposition is that of nasal and oral stop, followed by the opposition of labials and dentals, and so on. The chronological succession of these acquisitions is surprisingly uniform. This is because it agrees exactly, Jakobson says, with the general laws of irreversible solidarity (or unilateral implication) which govern the synchrony of all the languages of the world and determine their phonemic inventories. One of these

laws is that fricatives presuppose stops, i.e. the intermediately close fricatives presuppose the maximally close stops, which afford greater contrast to the vowels. Therefore, fricatives are acquired only after stops have been acquired. These laws and the principle of maximal contrast govern the step-by-step development of the phonemic system. At each progressive stage, neutralizations of certain oppositions are suspended, and thus the phoneme inventory increases.

Sounds may be allophones before they become phonemic. For example, Jakobson (1968) says that often a narrow and more front vowel (e.g. [ɛ]) appears in the beginning simply as a variant of the fundamental vowel [a], which is either optional (papa may vary with pɛpɛ) or combinatorial: usually [a] after labials, [ɛ] after dentals. But as soon as both vowels become separate phonemes, "the child attempts to intensify the difference of wideness and [e] is narrowed to [i]."

Similarly, Velten (1943) says that in the 25th month [ɪ] appears as an allophone of short [u] before dentals (first in sɪt, 'sit') in accented syllables. Accordingly, fut 'foot', dud 'good', bus 'bush', futs 'fix', etc. change to fɪt, dɪd while fup 'whip', fub 'swim', etc. retain [u]. But the phonemic opposition (u/ɪ) is not established until the 36th month.

Now these analysis are clearly wrong. A child who acquires a high vowel, e.g. [i] does not substitute this for the [ɛ] allophone he may have used for [a]; rather the [ɛ] remains an alternate of [a], and the new [i] represents vowels distinct from either [ɛ] or [a]. A child does not change dɛdɛ 'dada' to didi upon acquiring [i]! Similarly, Joan Velten's allophone [ɪ] for [u] as in fɪt 'foot', did not "become" a phoneme. Upon acquiring the [ɪ]-phoneme distinct from [u], the vowel of fɪt reverted to [u]. Jakobson and Velten's mistake was possible only because they ignored the substitutions that were being made.

Since Jakobson analyzes the child's system as a separate entity, without reference to the adult system, the child's phonemic system may at any point be non-congruent with the adult system. This means that the child may have phonemic distinctions not found in the adult system. For example, an English child may have a vowel length distinction.

The special difficulty with this type of analysis is that it is nearly impossible to get the substitutions, and thus the processes, from the data. Substitutions cannot be gleaned from the phoneme system, although the phoneme system can always be deduced from the substitutions. Velten does give a few equational-type statements such as "p/b for English [p, b, v-]" (Velten 1943), but these are of little help, especially since he chooses very few exemplary words, and does not attempt to give many of the "homonyms" represented by a form. The model makes such statements as these mere optional footnotes to the description.

The model which followed in this paper differs greatly from those outlined above. It is that proposed by Stampe (1969).

In Stampe's view, the child's pronunciation is derived from his mental representation of adult speech. This mental representation corresponds approximately to the adult surface pronunciation and is the child's underlying representation. An innate system of phonological processes operates on this representation. The innate system expresses the full system of restrictions on speech: a full set of unlimited and unordered phonological processes. Thus in early stages when all of these processes are applying in unordered fashion, simple sequences like dadada, mamama appear. Each new phonetic opposition the child learns to pronounce involves some revision of the innate phonological system. Changes in the child's phoneme inventory are merely one of several secondary effects of a change in the system of processes. The mechanisms of revision are suppression, limitation, and ordering: thus, the child's task in acquiring adult pronunciation is to revise all aspects of the system which separate his pronunciation from the standard. If he succeeds, the resulting system will be equivalent to that of standard speakers (444). The child's closer approximations of adult pronunciation are seen as reflecting his limitations or suppressions of those processes which are not common to the adult system.

According to Stampe, there is no need to refer to implicational laws such as Jakobson proposed. The regularities in the order in which phonetic representations are mastered can be explained by independently attested properties of the innate system (its processes, their inner hierarchies, and their interrelations) and by the three mechanisms whereby the innate system is revised (445). Moreover, there may arise contradictions to the order of acquisition predicted by the implicational laws. Jakobson, being interested only in the phoneme system, can ignore such problems by interpreting the implicational laws in terms of phonemic representation. Since he does not have to account for contextual variation, he can disregard context-sensitive processes which may contradict his implicational laws. The inventory is set up without regard for neutralization in some of the forms as long as sounds are phonemic elsewhere. It follows that the implicational laws cannot even account for the phonemic representation, but only for the phonemic inventory. Stampe says that these implicational universals are actually just innate universal phonological processes which govern phonetic (not underlying) representation and which have to be ordered for acquisition. The child has to unlearn those not appropriate to his language.

Jakobson claims that the child may create an opposition which does not exist in the adult language, but this is impossible if the child has the adult system underlying. Stampe sees no evidence that the child has a phoneme system of his own. In fact there is counter evidence; see my remarks above on the claim that the child converts allophones to phonemes. It appears that the child has internalized a representation which transcends his own productions and forms the base on which the innate system of processes operates.

1.4. Symbols and Terms

All the symbols and terms are used with their usual values. The only questionable term is "Retroflexion." This name (like the others) is not meant to have physical phonetic reference. Not all r's are "retroflexed," in the strict sense. The term deretroflexion merely indicates a "loss of r-ness," leaving a purely vocalic sound.

2. Processes Found Affecting Liquids in the Children's Speech

2.1. Processes Directly Affecting Liquids

The main processes found to be operating directly on liquids involve a simple delateralization of l, and a "loss of r-ness" (or "deretroflexion") for r. The numbering used here is the numbering found in the list of processes in Appendix A. Delateralization is L3:

(L3) $\begin{bmatrix} -\text{coronal} \\ +\text{sonorant} \\ \pm\text{velar} \end{bmatrix} \rightarrow$ [-lateral]

i.e. a) $\begin{bmatrix} +\text{sonorant} \\ +\text{velar} \end{bmatrix} \rightarrow$ [-lateral]

$u^{l} \rightarrow \underset{\curvearrowright}{u}$

b) $\begin{bmatrix} +\text{sonorant} \\ -\text{velar} \end{bmatrix} \rightarrow$ [-lateral]

$\underset{\curvearrowleft}{i}^{l} \rightarrow \underset{\curvearrowright}{i}$

Deretroflexion is R2:

(R2) Sonorant → -R

i.e. a) r → $\underset{\curvearrowright}{o}$ $\begin{bmatrix} -\text{coronal} \\ +\text{Rnd} \\ +\text{BK} \\ +\text{retro} \\ -\text{stress} \end{bmatrix}$

b) r → ə $\begin{bmatrix} -\text{coronal} \\ -\text{Rnd} \\ +\text{BK} \\ +\text{retro} \\ -\text{stress} \end{bmatrix}$

c) $\acute{r}$ → ó (more exactly $\acute{o}^{ə}$) $\begin{bmatrix} -\text{coronal} \\ +\text{Rnd} \\ +\text{BK} \\ +\text{retro} \\ +\text{stress} \end{bmatrix}$

These processes result in a vocalic substitute whose syllabicity and quality depend on the syllabicity and vocalic quality of the underlying liquid. Since nonvelar l has basically an i-quality, its delateralized substitute would be a palatal, eventually y. However, l may be labiovelarized as in L1:

(L1) $l \rightarrow \begin{bmatrix} +\text{Rnd} \\ +\text{velar} \end{bmatrix}$

Its nonlateral substitute is a labiovelar or u-quality vowel. The contexts for (L1) vary, depending on the child, much as its degree of generality varies in English adult speech (see Appendix B). We do not expect the child's speech to reflect a more limited context for the process than does his adult model. In fact, we expect it at first to be less limited, if possible, and indeed this is the case with most of the children studied.

Since r has a ə-like quality, loss of its r-ness leaves a velar glide in most cases. However, as in adult idioms, r is labialized or rounded in certain contexts. R1 gives the process in its strongest form, with no contexts specified.

(R1) $\begin{bmatrix} r \\ \pm\text{syllabic} \end{bmatrix} \rightarrow [+\text{Rnd}]$

Therefore, upon deretroflexion, according to process R2, we get three distinct substitutes. For unstressed nonsyllabic r, we have nonsyllabic o or ə, depending on whether or not there is rounding, and for stressed syllabic $\overset{r}{\underset{w}{}}$ we have syllabic ó. More precisely, we have a vowel with a nonround off-glide $\widetilde{o^{ə}_{\wedge}}$, because stressed syllabic r typically seems to end in a non-labialized r-glide. I have omitted this detail from the formulation of the processes, but it invites further study. Since American [r] is already [-coronal], there are only two (R) rules.

Process L2, Loss of Coronality, says that all l's become noncoronal (apical).

(L2) [+lateral] → [-coronal]

i.e. a) $\begin{bmatrix} l^{w} \\ +\text{velar} \\ +\text{Rnd} \end{bmatrix} \rightarrow \underset{\wedge}{u}^{l}$

b) $\begin{bmatrix} i \\ -\text{velar} \\ -\text{Rnd} \end{bmatrix} \rightarrow \underset{\wedge}{i}^{l}$

L3 is the important process of delateralization by which [-conronal] sonorants (especially [+round], [+velar]) become [-lateral].

2.2. Processes Indirectly Affecting Liquids

There are four other processes encountered in the children's speech which affected liquids indirectly, by applying to their substitutes. Process A raises $[\underset{\wedge}{o}]$ and $[o^{ə}_{\wedge}]$ resulting from R2 to $[\underset{\wedge}{u}]$ and $[u^{ə}_{\wedge}]$, respectively.

(A) Raising $\begin{bmatrix}+\text{vocalic}\\+\text{Rnd}\end{bmatrix} \rightarrow [+\text{High}]$

i.e. a) o → u

b) $o^{\partial}_{\wedge} \rightarrow u^{\partial}_{\wedge}$

There do not seem to be any conditions for this rule. Perhaps it is "optional" or "morpheme-specific" but it does take place in most words, and it is similar to a process William Labov (1963) finds taking place in New York City dialects, where, e.g. [dɔ$^{\partial}_{\wedge}$g] 'dog' may become [du$^{\partial}_{\wedge}$g].

Process B, Glide Loss, says that the round glide [u̯] is lost. This handles the glides resulting from both l's and r's. The contexts vary, depending on the children.

(B) Glide Loss $\begin{bmatrix}+\text{round}\\ \text{glide}\end{bmatrix} \rightarrow \emptyset$

Process C, Strengthening, says simply that the glides i̯ and u̯ become y and w, respectively. The strongest form of the process says that this strengthening happens in syllable initial position (. indicates syllable boundary), after a syllable initial consonant, or between vowels.

(C) Strengthening glide → [-vocalic] / $\begin{Bmatrix}.(C)\\ V\end{Bmatrix}$ _ V a) b)

i.e. i̯ → y

u̯ → w

Process D is Absorption of nonsyllabic ə̯ by a preceding vowel.

(D) Absorption ə̯ → ∅ / [+vocalic] _

The processes, as discussed above, are in their strongest form. They will be limited and suppressed, and this will take place chronologically earlier in some positions than in others, and the particular order will be different with the different children.

For some of the children, additional processes are needed. These are special late processes which have very limited application. They are not general for all of the children. These are mentioned wherever they are needed to explain a substitution found in the speech of one of the children, and they are included in the summary in Appendix A.

The acquisition process is divided into stages, numbered by the year and the month. Forms are given for each stage. The variant forms which appear in the data result from the fact that children sometimes gave the same word several different ways on a single day.

There are also many cases of optionality. I am considering this as a "conditional" sort of limitation/suppression. Apparently some rules simply become optional, and we cannot state conditions saying exactly when they will apply.

3. Individual Case Studies

3.1. Daniel

The first child is Daniel, for whom I have data for the ages 1.6 to 3.1. At the first stage, all the major processes apply. Daniel labiovelarizes l's in all postsegmental contexts. The only l's excluded are initial ones. This is as it should be for him, since the only substitute ever found for initial l is y. In Daniel's parents' dialect it applies to l only in syllable offsets, but Daniel's older sister, Eve, had the process in its unlimited form and labiovelarized all l's.

(L1) $$l \rightarrow \begin{bmatrix} +\text{Rnd} \\ +\text{velar} \end{bmatrix} \; / \; [\;]_$$

L2b, Loss of Coronality, is limited for Daniel as follows:

(L2b) $$\begin{bmatrix} -\text{velar} \\ -\text{Rnd} \end{bmatrix}^{l} \rightarrow [-\text{coronal}] \; / \; _ \begin{bmatrix} \text{High} \\ \text{V} \end{bmatrix}$$

For the r's, there is labialization according to R1 in three environments. Daniel has the rule in the form:

(R1) a) $$\begin{bmatrix} r \\ \pm\text{syll} \end{bmatrix} \rightarrow [+\text{Rnd}] \; / \; \left\{ \begin{matrix} .C_o_ \\ +\text{stress} \\ \overline{V_V} \end{matrix} \right\}$$

Part a) says that r's are labialized if they are syllable initial or follow one or more syllable initial consonants. Part b) says that r's are labialized when they are stressed, and part c) labialized intervocalic r's.

Process B, Glide Loss, has the following form for Daniel:

(B) $$\begin{bmatrix} +\text{Rnd} \\ \text{Glide} \end{bmatrix} \rightarrow \emptyset \; / \; \left\{ \begin{matrix} \text{V_C} & \text{a)} \\ .\begin{bmatrix} \text{cor} \\ \text{cons} \end{bmatrix} \text{_V} & \text{b)} \end{matrix} \right\}$$

This says that the round glide [u̯] is lost (a) between a vowel and a consonant and (b) between a syllable initial noncoronal consonant and a vowel.

For Daniel Process D, ə-Absorption, occurs only after back vowels:

(D) $\underset{\wedge}{ə} \rightarrow \emptyset \; / \; \begin{bmatrix} +\text{voc} \\ +\text{Bk} \end{bmatrix} _$

With all these processes applying, we get, at 1.6 and 1.7, for l's:

ball [bɑ́ɤ̯], milk [mʌ́k]
glasses [kaka]
lookie [yʊ́ki], lion [lɑ̃]

For r's we find forms like:

rockie [wɑki], chair [tʰʃə], car [kʰɑ́]
birdie [bʊ́i], park [pʰɑ́kʰ], Mary [mɛ́wi]
grandma [gɛ́mə], truck [twʌ́k]

At the next stage, 2.5, process B, part (a) is limited since milk is [mɛ́ɤ̯k], with a glide, but wolf is [wʊ́f]. The process is limited so that:

(B) $\begin{bmatrix} +\text{Rnd} \\ \text{glide} \end{bmatrix} \rightarrow \emptyset \; / \; \begin{bmatrix} +\text{High} \\ +\text{Bk} \\ \text{V} \end{bmatrix} _$

This is a kind of absorption of [u̯] by a preceding similar vowel. L2b is unchanged since:

Lizzie [yízi], but lantern [lɛ́ntən]

Process B, part (b), as limited above, is optional at this stage.

blue [bwʊ́], front [fwʌ̀nt], but
flowers [fɑ́ɤ̯əz]
glider [gɑ́i̯də], bullfrog [bʊ́fɔg]

At this same stage (2.5), the main change with l's is that Delateralization (L3a) is limited in final position. We find circle, turtle, people, and ball with final [u̯ˡ] from L2A, but seal is [sʃu̯] without the lateral.

circle [sɻkɤ̯ˡ], turtle [tʊ́ɚ̯dɤ̯ˡ]
people [pʰʃpəɤ̯ˡ], ball [bɔ́u̯ˡ]
seal [sʃu̯]

The word circle occurs at this stage with the correct stressed syllabic [r̩]. Since the rule for deretroflexion is still needed for several other forms of the same type, I am regarding this isolated word as an exception, or precursor of what is to come.

Process D, ə̯-Absorption, is limited here. The ə̯-glide is absorbed only after low back round vowels.

(D) $\overset{\circ}{\text{ə}} \rightarrow \emptyset \;/\; \begin{bmatrix} +\text{Low} \\ +\text{Bk} \\ +\text{Rnd} \\ \text{V} \end{bmatrix} -$

birdie [bə́˚ (ə)di]
horsie [hóə̯˚si]

At the next stage, 2.6, process L2a, Loss of Coronality, has become optional, since we find l's occurring in:

blocks [blʷɔ́ks], flags [blʷǽgz], blue [blʷú]

but some other words have w's;

airplane [ǽphwe̯˚n], play [phwé̯˚]

and others have no trace of l or w:

clap [khǽp] clown [khǽu̯˚n]

The optionality of the process is shown clearly by the word plate, which occurs in the three possible forms:

[phé̯˚t], [phwé̯˚t], [phlʷé̯˚t]

Rule B, Glide Loss, part (b), is optional, as it was at 2.5. This accounts for the forms for clap, clown, brush, brown, broke, and cream, some having w's and some having a zero substitute:

clap [khǽp], clown [khǽu̯˚n], brush [bʌ́s], brown [bʌ́u̯˚n]
broke [bwɔ́k], cream [kwím]

By stage 2.8, there have been a number of changes. Nearly all the processes concerning l's have been suppressed, and most l's are "normal," as in apple, flower, balloon, etc.

[hǽpl̩ʷ], [fəlʷáu̯˚r̩], [bəlʷún]

More r's are appearing at this stage. R2, Deretroflexion (a and b) is limited, or better, optional, since limiting conditions are not evident. Room appears with an initial r, but red and Ringo still have w.

[rúm], [wɛ́d], [wíŋgo]

Crayons has a correct postconsonantal r. Teacher and picture have final r's, but together still has a final ə:

[thʃtsr̩], [phʧtsr̩], [thəgɛ́zə]

Process B, part (b) is optional here, as before, but the frequency of its application is decreasing.[1]

froggie [fɔ́gi], but bricks [bwɪ́ks], tree [twɪ́]

The only change at 2.10 is a limitation of Deretroflexion in intervocalic position, since pirates and fairy have correct r's.

[pʰáɪ̯rɛts], [fɛ́ri]

At 2.11 a few vestiges of the l processes show up. For example, seal is found in two forms:

[sɪ́l] ~ [sɪ́u̯]

R2, Deretroflexion (a and c) is optional in several positions. In initial position, we find r's in red and great (initial g is lost), but rabbit appears both with r and with w.

[rɛ́d], [réɪ̯t], [wǽbɪt] ~ [rǽbɪt]

For postconsonantal r's, correct r's are found in tree, three, green, and dragon, but w's are still found in try, string, and break. However, the r's here are actually intervocalic because Daniel inserts epenthetic ə's at this stage to break up clusters. Also, initial t's and st's before r's are realized as s's at this stage.

[sərí], [gərín], [dərégn̩], [səwáɪ̯], [səwín], [bəwéɪ̯k]

In intervocalic position, orange and Mary have w's, but very has an r.

[ɔ́wɪnǰ], [mɛ́wi], but [vɛ́ri]

For preconsonantal r, the Deretroflexion process has finally become optional:

turtle [tʊ́ə̯dl̩] ~ [tɪ́dl̩]

At the last stage, 3.1, there is no evidence of the processes affecting l's, and we find near-adult forms like little, wolf, blue, rolling:

[lɪ́tl̩ʷ], [wʊ́lʷf], [blʷú], [róʊ̯lʷɪn]

However, the processes affecting r's are not yet entirely suppressed; part (a) of Deretroflexion, R2, is suppressed, since we find forms like:

[drɪ́ŋkt], [bráʊ̯n], [ɔ́rɪnǰ], [gərɪ́lə]

As before, part (b) of R2 is optional in final position, and robber appears both with final r and with final ə:

[rɔ́bə] ~ [rɔ́bɹ̩]

Part (c) of R2 is optional. Turn and work have correct stressed [ɝ] but bird and worm have [uɝ], and turtle appears both ways:

[thɝ́n], [wɝ́k], [bṵ́əd], [wṵ́əm], [tṵ́əd!] ~ [tɝ́d!]

Forms like these last are interesting, since they show an on-going process of suppression.

We see that by 3.1 Daniel has successfully suppressed or limited several of the innate processes, and is therefore much closer to the adult system.

3.2. Suzanne

The second child is Suzanne, for whom I have data from 2.10 to 3.1. From the beginning of this period she has correct initial and intervocalic l's. Therefore, she has already suppressed L2a, Loss of Coronality, in intervocalic position and L2b in initial position:

2.10 library [lá̰ɪfæri], light [lá̰ɪt], lion [lá̰ɪn̩]
2.11 leaves [lívz], living room [lívɪvŋ]
3.0 lamb [lǽm]
3.1 lady [lḛ́ɪdi], learned [lɝ́nt]

L1, Labiovelarization, is limited for Suzie so that only postsegmental l's are labiovelarized.

$$(L1)\quad l \rightarrow \begin{bmatrix} +\text{Rnd} \\ +\text{Velar} \end{bmatrix} \quad / \; [\;\;] _$$

L3a, Delateralization, is optional in final position at this stage, but L1 and L2a are needed for most of the forms.

$$(L3a)\quad \begin{bmatrix} \text{Son} \\ +\text{Velar} \end{bmatrix} \rightarrow [-\text{Lateral}] \; / \; __ \; \# \qquad \text{optional}$$

bottle [bʌ́tɤ̰(ɪ)], people [phípəṵ(ɪ)], but apple [ǽpəṵɪ]
turtle [thɝ́tṵɪ]

Neither L2 nor L3 apply in the forms for candle, squirrel, or uncle.

[khǽn!ʷ], [skwɝ́!ʷ], [ɔ́kh!ʷ]

L2a, Loss of Coronality is also optional in postconsonantal position at 2.10; and B, Glide Loss, is limited.

(L2a) $\begin{bmatrix} l^{w} \\ +\text{velar} \\ +\text{Rnd} \end{bmatrix} \rightarrow [-\text{coronal}]^{l} \; / \left\{ \begin{matrix} C__ \\ __\; \# \end{matrix} \right\}$ optional

(B) $\begin{bmatrix} +\text{Rnd} \\ \text{Glide} \end{bmatrix} \rightarrow \emptyset \; / \; \begin{bmatrix} +\text{Hi} \\ +\text{Bk} \\ \text{V} \end{bmatrix} _\; C$

2.10 milk [mɪ̯ɣk], glasses [gwás ɨz], but floor [flóɹ]
2.11 told [tó̯ʊ̯d]

By 2.11 there is no evidence for L3a (Delateralization)in final position, and only one word shows the application of L2a (Loss of Coronality). Most final L's are normal.

owl [æ̯ʊ̯ˈ], but school [skúˈʷ]
dimple [dɪ́mpl̩ʷ], pill [pɪ́l̩ʷ]

L2a is also suppressed for postconsonantal l's.

2.11 plastic [pʰlǽstɪk]
3.0 Santa Claus [sǽnəklɔz], flash [flæ̌š]
3.1 slide [slá̯ɪ̯d], play [pʰlé̯ɪ̯], clean [kʰlɪ́nt], etc.

By 3.0 and 3.1, L2 and L3 have been suppressed in final and preconsonantal position.

3.0 bottle [bɔ́dl̩ʷ], candle [kʰǽnl̩ʷ]
sail boat [sé̯ˈʷbo̯ʊ̯t], mail box [mé̯ˈʷbɔks],
spilled [səpɪ́ˈʷd]
3.1 school [skúˈʷ] or [skúl̩ʷ], angel [æ̌nǰl̩ʷ]
animal [ǽnml̩ʷ], bottle [bɔ́tl̩ʷ] or [bɔ́dl̩ʷ]
spilled [spɪ̀ˈʷdɨd], milk [mɛ́ˈʷk]

Vestiges of the processes show up in soldier at 3.1.

soldier [sóɣǰə]

Most r's are acquired by Suzie even at 2.10. R1, Labialization, is optional in initial position.

(R1) $\begin{bmatrix} r \\ \pm\text{syll} \end{bmatrix} \rightarrow [+\text{Rnd}] \; / \; \#__$ optional

R2a, Deretroflexion, is optional in initial, intervocalic and postconsonantal positions.

(R2a) $\begin{bmatrix} r \\ w \end{bmatrix} \rightarrow \underset{\wedge}{\text{o}} \; / \left\{ \begin{matrix} \#__ \\ V__V \\ C__ \end{matrix} \right\}$ optional

R2b is optional in preconsonantal and final positions.

(R2b) (r → / _ $\left\{\begin{matrix} C \\ \# \end{matrix}\right\}$) optional

and R2c is suppressed (stressed [ɹ̩́] is correct). A, Raising, and C, Strengthening, are operating; but B, Glide Loss, is optional in preconsonantal position.

(B) $\begin{bmatrix} \text{glide} \\ +\text{Rnd} \end{bmatrix}$ → ∅ / C_ optional

Initial: raisins [wéɪsə̃nz] ~ [réɪsə̃nz], rabbit [rǽbɪt]
Intervocalic: library [láɪfɛ̀ri], carrot [kʰɛ́rət],
Postconsonantal: brings [bwɪ̃ŋz], but (eye) brows [bráʊ̯s], brush [brʌ́š], giraffe [drǽf], hungry [hʌ́ŋgri]
Preconsonantal: years [ɹ̩əz], but guitars [gɪtɑ́rz], party [pɑ́rt̬i], girl [gɹ̩̀], bird [bɹ̩̀d], nursery [nɹ̩̀sɛri], turtle [tɹ̩̀tɨ̯], turkey [tɹ̩̀ki], etc.
Final: floor [flɔ́ɹ̩], alligator [ǽləgeɪ̯tɹ̩], bear [béɪ̯ɹ̩], sister [stɪ́stɹ̩]

At 2.11 R2, Deretroflexion is almost entirely suppressed. R2a is suppressed in initial position, and R2c is suppressed in preconsonantal position. R2b is nearly suppressed in final position.

Initial: raisins [réɪsn̩z]
Final: sister [stɪ́stɹ̩]
Preconsonantal: university [junɪvɹ̩̀sɪsti], purse [pɹ̩̀s][2]
Postconsonantal: eyebrows [ɑ́ɪ̯baʊ̯]
Intervocalic: Mary [mɛ́wi], Suzie Robinson [suzirɔ́bsn̩] kangaroos [kʰæŋərúz]

At 3.0 and 3.1, nearly all of the processes affecting r's are suppressed. R2a is suppressed in intervocalic position, although one word shows its operation in initial position. R2b is almost suppressed, but again a few words show its application in preconsonantal and final position. R2c is suppressed in postconsonantal and intervocalic position, and D, ə-Absorption, is suppressed.

Intervocalic: carrot [kʰɛ́rənt̬ʰ], three [θərí], Mary [mɛ́ri] tomorrow [t̬ʰəmɔ́rn̩], ironing [ɑ́ɪ̯rɪŋ]
Initial: read [wɪ́d] rabbit [rǽbɪt̬], rubber [rʌ́bə]
Preconsonantal: barn [bɑ́rn], airplane [ɛ́rplé͡ɪn], airport [é͡ɪpɔrt̬ʰ], reindeers [ré͡ɪndɪəz]
Final: pacifier [pʰǽsfaɪ̯ə], soldier [sóʊ̯ɟə], bear [béɪ̯ə] pour [pʰóə], finger [fɪ́ŋɹ̩], sister [stɪ́stɹ̩]
Postconsonantal: aspirin [ǽsprɪn], camera [kʰǽmrə], Chris [kʰrɪ́st], frog [frɔ́g], angry [ǽŋgri], dress [dərɛˢ], bird [bɹ̩̀d],[3] university [junɪvɹ̩̀sti], learn [lɹ̩̀nt]

3.3. Eleni

The third child is Eleni, for whom I have records for 2.1 to 2.8. Again, most substitutions are explicable within the framework already presented. In some cases this is not as clear as it might be because Eleni is behind the others in the acquisition process. Since she shortens words drastically, it is sometimes hard to tell exactly what processes are operating. For example balloon is [bú], presumably via

[bəlún] → [blʷún] → [bwún] → [bún] → [bú]

but we cannot be sure of this.

At the first stage, 2.1, there is evidence for most of the process. We have evidence later that initial l's are not labio-velarized. Therefore L1 has this limited form for Eleni:

(L1) $l \rightarrow \begin{bmatrix} +\text{Rnd} \\ +\text{velar} \end{bmatrix} \quad / \; [\;\;] _$

Initial y glides do not show up, but some y-glides appear in final and preconsonantal position. Therefore, B, Glide Loss, is limited somewhat.

(B) $\begin{bmatrix} \text{glide} \\ -\text{Rnd} \end{bmatrix} \rightarrow \emptyset \; / \; \# \; __ V$

$\begin{bmatrix} \text{glide} \\ +\text{Rnd} \end{bmatrix} \rightarrow \emptyset \; / \; \left\{ \begin{matrix} (V __ \#) \\ .C __ V \end{matrix} \right\}$ optional

Initial: lookie [ʷkí]
Final:[4] ball [bɔ́ʸ] ~ [bɔ́], owl [áʸ], doll [dɔ́]
Preconsonantal: milk [máʸk]
Postconsonantal: glasses [gǽ·]

For r's, Labialization, R1, is limited for Eleni to:

(R1) $\begin{bmatrix} r \\ \pm\text{syll} \end{bmatrix} \rightarrow [+\text{Rnd}] \; / \; \left\{ \begin{matrix} .\text{Co} __ \\ +\text{stress} \\ V __ V \end{matrix} \right\}$

Process D, ə-Absorption, is also limited. It applies after low back vowels, but is optional after other vowels.

(D) $\underset{\wedge}{ə} \rightarrow \emptyset \; / \; \left\{ \begin{matrix} \begin{bmatrix} +\text{low} \\ +\text{Bk} \\ V \end{bmatrix} __ \\ (V __) \end{matrix} \right\}$ optional

R2, Deretroflexion, applies in most words, but R2c is optional in preconsonantal position.

(R2c) $\begin{bmatrix} \acute{r} \\ w \end{bmatrix} \rightarrow o^{\circ}_{\wedge} \; / \; __C$ optional

Final: car [ká], door [dó$_{\wedge}^{\circ}$] ~ [dɔ́]
Preconsonantal: horse [hɔ́s], marble [má?]
birdie [bú$_{\wedge}^{\circ}$i], but dirty [dɨ̀]

At 2.2 the situation is nearly the same; L3a, Delateralization, is optional in preconsonantal position (see belt), and one word indicates that it is being suppressed in final position. (Ma)gill, the cat's name, appears a few times with the lateral. It is indicative of a later stage. Loss of initial y-glide (B above) is being suppressed.

Initial: look [ʌ́k] ~ [v̋k], lookie [v̋ki]
leaf [yí], lion [yá$_{\wedge}^{\circ}$n], light [yá$_{\wedge}^{\circ}$]
Final: ball [bɔ́$_{\times}^{\circ}$], Gill [gæ̋$_{\times}^{\circ}$] ~ [gɪ́$_{\times}^{\circ}$] ~ [gɪ́·u$_{\wedge}^{\circ}$], turtle [tɨ̀u]
circle [sɨ̀gau$_{\times}^{\circ}$], owl [áu$_{\times}^{\circ}$], tail [té·u]
apple [ǽku], but girl [gú] ~ [góu$_{\times}^{\circ}$], school [gú·],
doll [dɔ́]
Preconsonantal: belt [bá$_{\times}^{\circ}$u(l)?]
Postconsonantal: flowers [fáu$_{\times}^{\circ}$ə(s)] ~ [fáu$_{\times}^{\circ}$], clock
[gák] ~ [kák], block [bák],
glasses [dǽs], slide [dá$_{\wedge}^{\circ}$]
plane [pé·] ~ [pé$_{\wedge}^{\circ}$n], flag [bǽk]
Intervocalic: balloon [bú(·)]

Concerning r's at this stage, Labialization, Deretroflexion, Raising, and Strengthening are needed to derive the forms with initial r's:.

rabbit [wǽbɪk] ~ [wǽbi], round [wáu$_{\times}^{\circ}$], red [wɛ́ki]

The same processes are evident for postconsonantal r's, although B, Glide Loss, usually applies.

brush [bʌ́s], drum [dʌ́m], crayon [ké] ~ [gǽm], frog [fɔ́?]
train [tɨ́$_{\wedge}^{\circ}$n], pretty [pwɨ́tɨ]

The form for pretty indicates that Glide Loss is beginning to be limited. However, since process B is still needed for most forms until 2.8, this may be just an exceptional word, far ahead of its time.

For words with final r's, Deretroflexion and ə-Absorption apply.

door [dó] ~ [dv̋], guitar [gɪtá], car [ká] ~ [kʌ́]
star [tá]
sugar [sv̋kə], picture [pɪ́tə]

The situation with preconsonantal r's is nearly the same as at the previous stage, except that R2c, Deretroflexion, is even more limited, since more cases of [ɹ̩ʷ] appear, and a few forms indicate that A, Raising, is optional.

horse [(h)ɔ̝ɚ̯s̆] ~ [(h)ɔ̝ɚ̯s̆] ~ [ɔ̝s̆] ~ [ʊ̝s̆]
card [gɑ̝·], George [dɔ̝]
church [cɹ̩?], turtle [tɹ̩u], circle [sɹ̩gəɤ̯]
Bird [bɹ̩] ~ [bʊ̝ə̯] ~ [bʊ̝], girl [gʊ̝] ~ [gɔ̝ɤ̯], turkey[tɔ̝ki]

Only one word, orange, is found which should have an intervocalic r. This appears as [ɔ̝ɚ̯?] in Eleni's speech, and it could indicate that Eleni does not labialize intervocalic r's, since Deretroflexion alone would give [ɚ̯], or the [ɚ̯] could be a normal off-glide of [o]. This cannot be checked because there are no other comparable forms.

The major changes for l's at 2.4 are that L2a, Loss of Coronality is being limited in final position, and is nearly suppressed in intervocalic position, and L3a, Delateralization (of velar sonorants) is being suppressed in final position.

Initial: lion [yɑ̝ɪ̯], look [ʊ̝k]
Final: owl [ɑ̝ʊ̯], Gill [gɪ̝ʊ̯], circle [sɪ̝kəɤ̯], ball [bɔ̝ʊ̯], school [gʊ̝ʊ̯], and animal [gæ̝mɪ̯], girl [gɪ̝ʊ̯] ~ [gɹ̩ʷ]
Postconsonantal: clock [kʰɑ̝kʰ], flower [fɑ̝ʊ̯], airplane [æ̝peɪ̯n]
Intervocalic: umbrella [bʌ̝ɪə], impala [pɑ̝ɪə]

For r's at 2.4, R2c (Deretroflexion of [ɹ̩ʷ]) is suppressed in preconsonantal position. One word, some more, occurs as an exception to R2b, and two words occur as exceptions to R2a in postconsonantal position. Otherwise, the situation has not changed since 2.2.

Initial: read [wɪ̝d]
Final: guitar [tʰɑ̝], car [gɑ̝] ~ [kɑ̝], zipper [zɪ̝pə]
bear [bɛ̝ə], tiger [tɑ̝ɪgə], deer [dɪ̝ə], paper [bɛ̝ɪpə]
upstairs [əpəstɛ̝ɪə], but some more [əmɔ̝r]
Preconsonantal: yarn [nɑ̝·n], airplane [æ̝peɪ̯n], horse [ɔ̝s̆]
girl [gɹ̩ʷ], turkey [tɹ̩kɪ], my turn [maɪ̯tʰɹ̩]
Postconsonantal: zebras [zɪ̝brə], throw away [frɔʊ̯wɛ̝ɪ̯]

At 2.6 there have been a few changes. For initial l's, the Glide Loss rule

$$\begin{bmatrix}\text{glide}\\ \text{-Rnd}\end{bmatrix} \rightarrow \emptyset \;/\; \#__$$

has been suppressed.

light [yáɪ̯t]

For final l's, some words indicate that L1, L2, L3 and loss of w-glide are still in operation.

animal [ǽm ə], apple [ʔǽpə], turtle [dɔ́də] ~ [dɔ́ɚdə]
doll [dɔ́], snail [snéˑɪ̯]

But, two words show that Glide Loss is partially suppressed.

Gill [gǽʊ̯], girl [gɪ́ʊ̯]

And one word, owl, shows a limitation of Delateralization (L3) in final position.

owl [áʊ̯ˡ]

Two words show that L2a, Loss of Coronality, is being limited in final position.

doll [dɔ́ˡʷ], ball [bɔ́ˡʷ]

L2a is also limited or optional in intervocalic position.

balloon [bəún], but umbrella [ədəbɹ́ˡʌ]

The other forms show no changes:

milk [mɔ́k]
airplane [ɛ́rpeɪ̯n], flower [fáʊ̯ə], sleepy [sɪ́pi],
block [bɑ́k]
floor [fɔ́ˑə], clock [gɑ́k]

By 2.5, R2b, Deretroflexion of r, has become optional in final position and preconsonantal position. The other forms show no change from 2.4.

Final: upstairs [əpəstéɪ̯ɹ] ~ [əpəstéɪ̯ə], but chair [sɛ́ɪ̯ə]
piece of paper [bɪsəbéɪ̯bə], somemore [əmóə],
there [dɛ́ɪ̯ə]
Preconsonantal: Marsha [mɑ́ʃə], horsie [hɔ́ɚsi] ~ [ʰɔ́si] ~ [ʰɔ́ʃi]
birdie [bʊ́ɚdi] ~ [bʊ́di], airplane [ɛ́(r)peɪ̯n]
my turn [maɪ̯tɚ̯n]
Postconsonantal: brush [bɹ́ʌs] ~ [bɹ́ʌʃ], truck [ʧɹ́ʌk]
ice cream [áɪ̯skɪm], throw away [θowéɪ̯]
train [ʧɛ́ɪ̯n] ~ [zɛ́ɪ̯n], dress [dɛ́s]

At 2.8, the last stage for which I have data, the main changes for l are the suppression of L2b, Loss of Coronality, in initial position, and the optionality of L2a in preconsonantal position.[6]

Initial:[7] look [lʌ́k]
Final: table [dé˛bəlʷ], but apple [ǽpu·], Gill [gíɣ]
pencil [bɛ̂nsu], cereal [sĭ·u], cradle [ké˛dəɣ],
hill [íú], Jill [zĭíɣ], circle [sf́kəɣ] ~ [sf́kə],
school [skúə], ball [bú·ə], rattle [wǽdə]
Preconsonantal: animals [ǽməlʷz], but milk [méɣk]
hold this [hóɣ˛ðɪs]
Postconsonantal: blue [bú·], flower [fáɣə], floor [fúə]
sleepy [sĭpi], playing [bé˛]

At 2.8, R2a, Deretroflexion, has become optional in initial position, and the other processes remain as at 2.6.

Initial: (a)round [wáɣn], rattle [wǽdə], but read [rĭd]
record [wɛ́kə] ~ [rɛ́kə]
Final: deer [dĭə] ~ [dĭr̥], bear [bé˛ə], tiger [dáɣgə]
flower [fáu(ə)], supper [sʌ́pə], here [hĭ·ə]
ear [ĭə], color [kádə], upstairs [ɛp(ə)sté˛ə]
Preconsonantal: Marsha [mɔ́šə] ~ [mɑ́šə], horsie [hɔ́šĭ]
circle [sf́kə] ~ [sf́kəɣ]
Postconsonantal: frog [fɔ́k], tree [fĭ], ice cream [ʌ́skim]
cradle [ké˛dəɣ], drinking [dɪ́ŋkɪŋ],
broke [bók], green [gĭən]

It appears that, although Eleni is behind the other children in her acquisition of liquids, the same general processes are evident in her progress.

3.4. Melissa

The fourth child is Melissa. She was slightly older when I observed her (3.1 to 4.1), but the substitutions found in her speech for l and r are derivable by the same processes. L's are nearly correct: L2a, Loss of Coronality, has been suppressed.

Final: squirrel [wírəlʷ], beautiful [búfəlʷ],
ball [bɔ́lʷ]
Postconsonantal: Kluge [klʷúgĭ], chocolate [šlʷɔ́klɪt] (3.1)
[čɔ́klʷɪt] (3.7)
Intervocalic: yellow [dzɛ́lʷo] at 3.4, coloring
[kʰʌ́lʷrɪn], at 3.7.

At the earliest stage, intervocalic l's are very tenuous. It appears for all these children that at early stages, intervocalic l's are subject to assimilation or some other modification. For example:

Molly [mɔ́ni], vanilla [nínə], Sally [sǽdĭ]
dolly [dɔ́dĭ]

For r's Melissa labializes r's as shown below:

$$(R1)\quad \begin{bmatrix} r \\ \pm syll \end{bmatrix} \rightarrow [+Rnd] \;/\; \left\{ \begin{matrix} .Co___ \\ +stress \\ V__V \end{matrix} \right\}$$

However, she has nearly suppressed R2, Deretroflexion. R2a is suppressed in intervocalic position, although it shows up somewhat in postconsonantal position. R2c applies infrequently in preconsonantal position. Processes R1, R2a, Aa, and C account for forms like:

write [wə́ɹt] at 3.7
brush [bwʌ́s] at 3.1

Loss of the glide (Process B) is shown in just one word:

ice cream [ʌ́ɹsfim] at 3.7

The other words show that R2a is nearly suppressed in post-consonantal position from 3.4 on.

3.4: thread [trɛ́d], Cricket [frɪ́kɪt], Chris [frɪ́s]
3.7: crib [trɪ́b], grandpa [drǽmpə], throw [frʌ́ʊ] ~ [fwʌ́ʊ], tree [frɪ́]
4.1: ice cream [ʌ́ɹstrim], Gretchen [drɛ́čɪn], across [ətrɔ́s]
Intervocalic: squirrel [wɪ́rəl] at 3.1

R2b is needed for most final r's at these stages. D, ə-Absorption is limited so that

$$ə \rightarrow \emptyset \;/\; \begin{bmatrix} +voc \\ +back \end{bmatrix} __$$

3.1: there [nɛ́ɹə]
3.4: sweater [twɛ́tə]
3.7: bother [bɔ́ðə], remember [mɛ́mbə], picture [phɪ́čə]
4.1: Christopher [trɪ́stəfə]

R2b and ə-Absorption account for apart at 3.7.[8]

apart [phɑ́·t]

R2c is nearly suppressed in preconsonantal position.

3.1: jersey [dɹ̩zi]
3.7: disturb [stɹ̩b], jersey [dʒɹ̩zi]

3.5. Jennifer

I have a few notes from David Stampe about his niece Jennifer's acquisition of liquids at one stage, 2.0. The forms found at

this time can all be explained by the basic processes we have been using. Jennifer labiovelarizes l's in post-segmental positions.

(L1) $l \rightarrow \begin{bmatrix} +\text{Rnd} \\ +\text{velar} \end{bmatrix} \; / \; [\;] _$

Lb2, Loss of Coronality, is suppressed entirely, and L2a is limited.

(L2a) $\begin{bmatrix} l^{w} \\ +\text{velar} \\ +\text{Rnd} \end{bmatrix} \rightarrow \overset{\frown}{u}^{l} \; / \; \left\{ \begin{array}{l} f__V \\ __ \left\{ \begin{matrix} C \\ \# \end{matrix} \right\} \end{array} \right\}$

Delateralization, L3, is in its normal form. B, Glide Loss, is limited to round glides in specific environments.

(B) $\begin{bmatrix} +\text{Rnd} \\ \text{glide} \end{bmatrix} \rightarrow \emptyset \; / \; \left\{ \begin{array}{l} V __ \left\{ \begin{matrix} \# \\ C \end{matrix} \right\} \\ C__V \end{array} \right\}$

These processes give the forms below:

Initial: look [lʷʊ̈t], lotta [lá] (via [lárə])
Final: ball [bɔ́·], tickle [tɪ́ku]
Preconsonantal: help [hɛ́p], animals [ǽmoz][9]
Postconsonantal: play [pl^{w}e·], blue [bl^{w}u·]
fly [fáɹ], flag [fǽɹd][10]

For r's, Jennifer labializes r's as follows:

(R1) $\begin{bmatrix} r \\ \pm\text{syll} \end{bmatrix} \rightarrow [+\text{Rnd}] \; / \; \left\{ \begin{array}{l} .C___ \\ +\text{stress}___ \end{array} \right\}$

Since no words occur with intervocalic r, we cannot tell if this should be included in the environment. R2, Deretroflexion, is taking place, and there is evidence for A, Raising, and B, Glide Loss, as given for l's. Strengthening (C) and ə-Absorption are also in operation. These give the forms:

Initial: red [wɛ́·d]
Final: other [ʌ́zə], water [wɔ́tə]
Preconsonantal: bird [bʊ̈·d]
Postconsonantal: frog [fɔ́·d], tree [tɪ·][11]

3.6. Emily

I have data for Emily Salus only at 1.7. It is interesting, however, because Emily consistently substitutes n for light l.

For her, L1, Labiovelarization, is limited and does not include intervocalic l's. She evidently has some late process by which light l's become n's.

(b) $$\begin{bmatrix} l \\ -\text{Rnd} \\ -\text{velar} \end{bmatrix} \rightarrow n$$

This substitution is not due to assimilation, since we find such forms as [ni] for Lee. It will be seen in Appendix B that the interchange of l and n is not an uncommon process. The other substitutions are easily accounted for by the processes as we have given them. The substitute for final l is w (presumably u in our transcription). This could be accounted for by L1, L2a, and L3a. Preconsonantal and postconsonantal l's have zero as the substitute. This can be explained by Labiovelarization (L1), Loss of Coronality (L2a), Delateralization (L3a), and Glide Loss (B).

4. Reanalysis of Studies from the Literature

4.1. Joan Velten

Joan Velten's progress is reported in her father's article (Velten 1943). Our same basic processes account for most of Joan's substitutions, but a few minor additions must be made. At every stage during the period (1.10 to 3.6), [z] is substituted regularly for initial l, and no word ever occurs with a correct initial l. Moreover, in a few words [z] is substituted for intervocalic l. If Joan has a limited form of Labiovelarization, excluding initial l's and some intervocalic l's, we can say simply that she has process L2b (Loss of Coronality), L3b (Delateralization) and C(Strengthening), but has an additional late process by which y's become z's.[12] So we just need to add an additional minor rule for Joan, ordered after Process C; and B, Glide Loss must be limited to exclude [-round] glides. Thus

(a) y → (ž) → z

This gives the correct forms.

Initial:	1.10:	light [zat], leaf [zuf], laugh [zaf]
	1.11-2.8:	lunch [zats][13] lion [zad], liver [zua], lap [zap], long [za·d], lake [zu·t], etc.
	2.6-2.9:	license plate [zasɪns pu·t]
	2.9-3.0:	love [zav]
Intervocalic:	1.10:	color [daz], Napolean [buz]

At the first stage, 1.10, L1, L2a, L3a, and B, Glide Loss, give the correct forms, except that Glide Loss is limited.

(B) $\begin{bmatrix} \text{glide} \\ +\text{Rnd} \end{bmatrix} \rightarrow \emptyset \; / \; \left\{ \begin{matrix} V __ \left\{ \begin{matrix} \# \\ C \end{matrix} \right\} \\ .C \; __ V \end{matrix} \right\}$

Final: fall [fu], sole [zu], wall [wu], hole [hu]
ball, bowl [bu], nail [nu], table [du bu]
noodle [nudu]
Preconsonantal: milk [mut], help [hup]
fly [fa], flap [fap], glass [das],
flower [fawa], block, black [bat],
blow, blue [bu]

At the next stage, 1.11 to 2.3, the major change with l's is the limitation of Process B, Glide Loss, in final and preconsonantal positions. Round glides are always lost after an u vowel, and are optionally lost after other vowels:

(B) $\begin{bmatrix} \text{Glide} \\ +\text{Rnd} \end{bmatrix} \rightarrow \emptyset \; / \; \left\{ \begin{matrix} u- \\ \left(V - \left\{ \begin{matrix} C \\ \# \end{matrix} \right\} \right) \end{matrix} \right\}$ optional

Final: all [a], doll [da], call [ta], ball [bu],
fall [fu], wall [wu], while [fa], pail, spill
peal, pole, pearl, pull, pool, spoil [pu]
well [waw],[14] smell [maw], bell [baw]
shell, shall [saw], gull [daw], owl [aw]
bubble [babu], people, purple [pu·bu]
Preconsonantal: wolf [wuf]
called [ta·d], cold [tu·d][15]
belt [bawt]
Postconsonantal: fly [fa], plumber [babu], plants [pats]
blocks [bats], clean [tu·d], slide [sa·d]
Intervocalic: belong [buza·d]
jelly [dawa], yellow [zawa], gallant [dawat]
Wallace [wawas]
pillow, peeler, pulling [pua]

At the last stage (through 3.0) there are no major changes.

Initial: love [zav]
Final: tell [taw], cocktail [ta·p-tu], uncle [antu]
Preconsonantal: child [ta·d], cold [tu·d]
Postconsonantal: clock [ta·t], cloth [ta·s],
airplane [u·-pu·d], plate [pu·t],
gloomy [du·mɪ], fly [faɪ]
Intervocalic: color [taz], telephone [tawafud]

The processes as I have formualted them account for most of Joan's substitutions for r's. Only a few minor additions must be made. For Joan, most r's are labialized except some in word final

position. Labialization is optional in final position. Those final r's which are not labialized show up as [a] instead of [ə] if the ə is not absorbed. Since Joan has no ə's in her inventory of sounds at these stages, she apparently has a late process.

(d) ə → a

This follows D, ə-Absorption (ə → ∅ / [+vocalic] _) which applies in all words except liver which is ahead of its time.

1.10: Initial: rose [wus], rough [waf], rabbit [wabut], room [wub], rain [wud], rock [wat], roof [wuf]
Final: bear [bu·], star [da], more [mu], ear [u], bear, bare, pare [bu], near [nu] sugar [zudu] liver [zua], tower, cover [dawa], flower [fawa], hammer [hama]
Preconsonantal: horse [us] > [hus], arm [am], bark [bat], board [but] nurse [nus], bird [but]
Postconsonantal: grandpa [daba] > [dap], broom [bub], train [dud], bread [but], drip [dup], dress [dus], brush [bas], brick, break [but][16]
Intervocalic: (to)morrow [maz] > [maza], Harry [haz] > [haza]

The substitution of [z] for intervocalic [r] at this stage is not accounted for by our processes. The expected substitute would be w which is the normal substitute at later stages. These r's are apparently not labialized. Then Joan may have another late process by which nonvelar r's become y. See Appendix A, R1 and R2d. Then the y would become [z], by the process given earlier.[17] (Appendix B has examples of the change of [r] to [z]).

At the next stage, 1.11 to 2.3, the situation is substantially the same. Glide Loss, B, is limited as it was for l's, and intervocalic r's are now labialized and become w's, if not lost.

Initial: right [wat], rubber [wabu], ring [wud], reach [wuts], red [wu·t] > [wud], rib, rim [wub], rouge [wu·z]
Final: far [fa], door [du] letter [zazu], paper [pu·bu], ladder [za·du] fire [faza], better [baza], grocer [du·sa]
Preconsonantal: morning [munu], dark [dat], yard [za·d] cord [tu·d], garbage [da·budz] pearl [pu], birdie [bu·du], hurt [hu·t] turn [tu·d], purple [pu·bu]

Postconsonantal: bread [but], broken [bu·du], grease [du·s], train [tu·d], green [du·d], probably [pabu] grocer [du·sa]
Intervocalic: sorry [sawa], Mary, marry [mawa], carry, cherry [dawa], paring, pouring, purring [pua], mirror [mua] worry [wua]

The rules as they are at the previous stage also account for most of the forms found at the last stage (2.6 to 3.0). Some final syllabic r's are still labialized and some are not, giving [u] and [a], respectively. Most of the processes are still operating, so that no trace is left of postconsonantal r or preconsonantal r (except for occasional lengthening of the preceding vowel). B, Glide Loss, is further limited so that the glide is not lost after vowels (see cigarette below).

Initial: red [wɪ·d], reader [wɪ·du]
Final: airplane [u·-pu·d], vinegar [vɪndu], reader [wɪ·du], farmer [fa·ma]
Preconsonantal: scarf [ta·f], tart [ta·t], stars cars [ta·z], davenport [dawaput], farmer [fa·ma], turn [tu·d]
Postconsonantal: crush [das], cross [ta·s], cream [tu·b], apricots [u·putats], cross-the-street [tasatu·t], apron [u·pɪn]
Intervocalic: cigarette [suduwɪt]

4.2. Hildegard Leopold

Hildegrad Leopold's acquisition of liquids is interesting for a number of reasons. First, her father kept a very complete record of her speech (Leopold 1947), and second, since she learned both German and English, we can compare her treatment of liquids in the two languages.

About the liquids, Leopold (1947:116) says that r and R were not "learned" during the first two years by Hildegrad, and l was not regularly articulated in the correct way. He also notes that English l and German l are treated differently because they differ in manner of production, the German l being articulated with a "flatter tongue" than the English, which is often accompanied by more or less "raising of the back (of the) tongue" (Leopold 1947:64).

Most of Hildegard's substitutions can be accounted for by the processes we have formulated. She does not labiovelarize as many l's, probably because of the influences of the German "clear" l. Her vocalic substitutes also show less uniformity, but we can account for this by late vowel changing rules.

English and German initial l's are treated similarly by Hildegard. Usually they are replaced by h or j(y), j being favored at the end of the period.[18] Initial l is correct in the last two months. Leopold says that j is easily understood as a substitute for l. The complicated continuant features are initiated incorrectly by the production of an easier neighboring continuant. Leopold interprets h as a form of omission, the presence of an initial consonant being vaguely indicated by the unchecked breath stream. See Appendix B for Grammont's explanation of the similarity of l and h. Gaberell Drachman (personal communication) has suggested a physiological explanation for this. He says that the tongue intrinsic horizontal muscle is not yet under control. So an l produced with a lowered tongue tip may be realized as h or z depending on the degree of approximation of the lowered tongue tip. This process would, then, also explain the l → (y) → z process found in the data for Joan Velten.

$$l \xrightarrow{L2,\ L3} y \rightarrow (\check{z}) \rightarrow \begin{Bmatrix} z \\ h \end{Bmatrix}$$

Then we can say that the h substitute is due simply to this late process accounted for by lack of tongue tip control. As this control is acquired, the process is suppressed, and j (or y, in our notation) is the substitute, explicable by Loss of Coronality, Delateralization, and Strengthening. (Glide Loss is limited and does not apply to most initial glides).

Initial: light [haɪ] ~ [aɪ] at 1.6, 1.8, 1.10, 1.11
look [hek] at 2.1
lie [jaɪ] at 1.11
like [jaɪ] at 2.1

For German words:

lutscht [juʃ], loch [jok´] ~ [lok´] at 1.10
Löscher [jokɛ] ~ [loka] at 1.11

The situation with final l's is more complicated. German and English final l's are treated differently. In many words final nonsyllabic l is omitted. This can be accounted for by processes L1, L2, L3, and Absorption of the glide. The substitute for English velarized l is often [ʋ], whereas [ɹ] is often found for German l.[20]

The contrast between German and English l shows up in ball:

Ball [baɪ] > [ba] at 1.5-1.8
ball [baʊ] at 1.9

The forms for rollen and roll suggest that the German and English words are in competition; the stressed vowels and palatals

point to German, while the [u] probably developed from English velar l.

[wɔ] ~ [wɔə] at 1.8
[wɔ:] ~ [wɔ:ɪ] ~ [wə|u] at 1.9
[wɔ] ~ [wo] at 1.11
[wo] at 2.1

Later [ə] is found for both [ɪ] and [ʊ]. In English this is often lowered to [a] or an intermediate vowel. This was regular in English after high front vowels. It was lowered after back vowels also in German, but not lastingly. Hildegard seems to have late processes whereby vowels are lowered or otherwise changed. This accounts for the variety of vowels.

(c2) $\left\{\begin{matrix} I \\ \breve{V} \end{matrix}\right\} \rightarrow ə \rightarrow a$ optional

A final l is achieved only in oil:

[ʔɔɪ] at 1.6
[ʔɔɪə] ~ [ʔɔɪ|ə] at 1.7

Final syllabic l's are not completely lost, but show up as a variety of vowels, in accordance with the above vowel changing process. Most nonsyllabic final l's are lost entirely at early stages. L1, Labiovelarization, is optional for final l's. L2, Loss of Coronality, and L3, Delaterization, are operating. Then B, Glide Loss, limited as below, gives zero as the substitute for final labiovelarized nonsyllabic l.

(B) $\begin{bmatrix} \text{glide} \\ +\text{Rnd} \end{bmatrix} \rightarrow \emptyset \; / \; \left\{\begin{matrix} C \\ V \end{matrix}\right\} \; _$

At 1.8 this process is further limited (see all wet), and more final glides appear. From 1.8 on Glide Loss is optional after [a] and most other vowels. Glides are always lost after [ɔ] and [o].

(B) $\begin{bmatrix} \text{glide} \\ +\text{Rnd} \end{bmatrix} \rightarrow \emptyset \; / \; \left\{\begin{matrix} C \; _ \\ \{ɔ\} \; _ \\ \{o\} \; _ \\ (\{a\} \; _) \\ (\{V\} \; _) \end{matrix}\right\}$ optional

The glides which are not lost are often changed (especially after high vowels) by the above vowel changing rule. The form for towel at 1.10 shows that L2, Loss of Coronality, is optional in at least this one word.

The following English forms are found with final l in the model:[21]

1.5: all [ʔa:]
apple [ʔapa] > [aba]
1.6: oil [ʔɔɪ]
bottle [baɪu] ~ [ba:ɪ]
1.7: oil [ʔɔɪə] ~ [ʔɔɪə], all [ʔa:]
bottle [ba·ɪ]
1.8: Paul [ba], all (wet) [ʔa] ~ [aʷwe]
wheel [wɪ·] ~ [wɔə]
apple [ʔapa], bottle [baɪu]
1.9: oil [ʔɔɪɔ], ball [baʊ], roll [wɔ:] ~ [wɔ:ɪ] ~ [wɔju] ~ [wɔɪu]
bottle [baɪu] ~ [baju]
1.10: oil [ʔɔɪo], all [ʔa] ~ [ʔa]
wheel [wi|]
bottle [baɪu], measles [mia], towel [daʊ(ɪ)]
1.11: fall [wɔ], roll [wɔ] ~ [wo], call [da] ~ [dɔ] [kɔ]
all [ʔaʊ] ~ [ʔa], ball, bell [baʊ], spill [bie]
bottle [baɪu], nail(s) [nea], pail [bea],
wheel [wiə] ~ [wia], towel [daʊ],
automobile [ʔatobiə]
2.0: all [ʔɔ:], fall [wɔ] ~ [fɔ] ~ [waʊ]
nail [nea]
2.1: ringbell [wibɔ], all [ɔ:], roll [wo], hole [ho]
automobile [ʔaʊto,biə]

For German final l's, processes L2 and L3 plus late vowel-changing processes give the following forms:

1.3: Ball [ba:ɪ]
1.8: dunkel [dʊdʊ] ~ [dɔdɔ]
1.9: dunkel [dɔkɔ]
1.10: dunkel [duko] ~ [dukɔ]
1.11: Nägel [nea]

There are few words with preconsonantal l. The most common is milk. It occurs with a [ə], which could possibly represent the German palatal or English velar l. It can be accounted for by the vowel-changing rule given above. In the other words the vocalic substitute is absorbed. Therefore process B, Glide Loss; as given earlier, is operating. Process D, ə̂-Absorption is optional here, since some ə's do appear.

1.6: milk [mɪ·]
1.7: milk [mɪə] > [mɪ]
1.9: milk [mea]
1.10 and 1.11: milk [mɪk][22]
cold [do] ~ [doi]
1.11: wheelbarrow [wibaʊ]

Postconsonantal l's are generally unrepresented (in German and English alike). We can account for most of the forms by

saying that Labiovelarization, Loss of Coronality, Delateralization, and Glide Loss apply.

block [bak̚] ~ [ba], please [bi], blow [bo] < [baʊ̯$_x$]
glass [das̚], airplane [ʔɛɪpi]

However, three words appear with initial w and one with initial j:

flower [waʊ̯] at 1.7 and 1.11
Florence [wos̚], fly [waɪ] at 1.11
slide [jaɪ] at 1.11

The occurrence of the w's could mean that B, Glide Loss, is being limited, but Leopold says that the w's are from the f's in these words (1947:67). Likewise we cannot be sure whether the j in slide results from an unlabiovelarized l or from s.[23]

Hildegard treats intervocalic l's differently, depending on whether the model is German or English. German intervocalic l's are never completely omitted. They occur as imperfect l, English velar l, j or correct l. The most frequent substitute is j because German intervocalic l's are not labiovelarized. Correct l's occur more often in the last two months. English intervocalic l, on the other hand, is usually omitted as late as 1.11. Leopold (1947:115) says that its omission may be connected with the standard raising of the back of the tongue. The front fricative is a less satisfactory substitute for it. Hello is found with a strongly velarized l from 1.5 on (a precursor of later events), but Helen has a j, indicating lack of labiovelarization. In the other cases L1, L2, L3 and Process B, Glide Loss, account for the forms. For postconsonantal and intervocalic l's, Glide Loss must be modified from the form given for final glides to include:

(B) $$\begin{bmatrix} \text{glide} \\ +\text{Rnd} \end{bmatrix} \rightarrow \emptyset \; / \; \begin{Bmatrix} C \\ V \end{Bmatrix} \; __ \; V$$

1.5: hello [ʔəlɔ]
1.6-1.11: dolly [da:i] ~ [da(·)ɪ]
1.9, 1.10, 2.0: Helen [haja]
1.10: balloon [bu:]
1.11: alley [ʔa·i], Alex [ʔa·i], pillow [bɪə] ~ [bɪa]
hello [joj], Mary Alice [mɛa'ʔa] ~ [mɛ'ʔa] ~ [mɛ'ʔaʊ̯]

Hildegard did not produce an r during the first two years. She either substituted something for it or omitted it. Leopold says (1947:164) that the chief characteristic of r is a moderately raised position of the tongue tip requiring complicated adjustment of the tongue muscles, difficult for children. Adding to the complication in this case is the fact that German uvular R is so different from English r. It is a velar spirant or roll or ev a velar fricative, but it is functionally

closely parallel to English r, and Hildegard treats them in much the same way.

The processes work out quite well for Hildegard's treatment of r. Initial r is replaced by [w] consistently, as we would expect. Leopold (1947:114) says that raising of the back of the tongue, essential for R is also registered as accompanying the articulation of [r]. The sound is thus akin to [u]. Before a vowel, this becomes the glide [w].

A few words do appear early with [h] or [j] for initial r. Leopold would explain the [h] as breath denoting the presence of some consonant. See Appendix B for processes changing [r] to [h]. Leopold (1947:114) says that [j] is an "unsuccessful rendering of the front part of r." Both of these early substitutes could be explained by the lack of muscular control, as for the l's at an early stage. The [w] substitutes in the other words are regularly derivable by Labialization, Deretroflexion, Raising, and Strengthening.

1.8, 1.10, 1.11, 2.1: ride [haɪ]
1.11, 2.0: room [hu]
1.11: write [jaɪ]
1.5: Rita [wiwi]
1.8: roll [wɔə], rock-a-bye-baby [wawa], allright [ʔawaɪ]
1.9: roll [wɔ:] ~ [wɔ:ɪ] ~ [wɔju] ~ [wɔiu]
1.10: radio [wea], rock-a-bye [wɔk,bebi], allright [ʔa'waɪ],
1.11: rock-a-bye-baby [wɔkə'bebi], roll [wɔ] ~ [wɔ], read [wi(ə)], ring bell [wɪbaʊ], right there [waɪt´(da)], a lright [ʔa'waɪ], Rita [wiwi]
2.1: ring bell [wibɔ]

With final r's, as with final l's, there is less uniformity. The vowel substitutes are of varying quality. Leopold reports that his final [R] has the North German colloquial pronunciation and is slurred to [ə] or is omitted, and after [a] is practically inaudible. So we are not surprised to find the nearly standard form of mehr [mea] at 1.5, and weisser [waɪsə] for Hildegard at 1.9.

Final r's are not labialized in Hildegard's speech. R1 has the following form.

$$(R1) \qquad \begin{bmatrix} r \\ \pm syll \end{bmatrix} \rightarrow [+Rnd] \quad \begin{Bmatrix} .Co__ \\ +stress \\ V__V \end{Bmatrix}$$

Then processes R2 (Deretroflexion) and D (ə-Absorption) account for most of the forms with final r's if we add to them some late minor rules to change [ə] to other vowels, ([i, ɪ, a] etc.) when it is not absorbed.[24] There do not appear to be any conditioning factors for these vowel changes.

0.10-1.4: there [dɛ(:)] ~ [dɪ:] ~ [dəi] ~ [da:]
1.5: high chair [aɪta], there [ʔə]
1.6: more [mɔ], there [da]
1.7: water [wa·] ~ [wɔ:ɪ], Jasper [dadi]
1.8: water [waɪʔ] ~ [wadə], here [hɪ], ear [ʔɛ·]
1.9: butter [bu:], here [hɪ]
1.10: door [do], poor [bu], there [da], where [we]
paper [bubu], cover [da], streetcar [dida],
dear [dia], hair [hea], ear [ʔiə], water [walu] ~
[waju] > [walu] ~ [wɔlu], bear [bɛa],
airplane [ʔeɪpi]
2.0: deer [dia], poor [pu]
2.1: where [wɛ]

Preconsonantal (nonsyllabic) r's are never represented, but if we assume the operation of the same processes as for final r's, we get the correct forms. There is compensatory vowel lengthening, at least optionally, when the [ə] is lost.

1.10: dark [da:t], (a)board [ʔabaʊ̯]
1.11 and 1.12: fork [hok] > [wɔ:k], New York [nɔjɔk]

One word is found which should have [$\overset{r}{w}$]. Instead of [$o^{ə}_{ʌ}$] → [$u^{ə}_{ʌ}$], which we would expect, [uɪ] is found.

1.10, 1.11: church [dʒuɪš]

This could be explained as a fronting of the [ə] before the palatal [š].[25]

Most postconsonantal r's leave no trace in Hildegard's speech. However, one word, pretty, is found early with [r] or some substitute, usually [w].[26] If this is considered to be an exceptional word, ahead of its time, then the other forms can be explained by the operation of Labialization, Deretroflexion, Raising, and Glide Loss.

1.1: Gertrude [də:di], pretty [pwɪti] until 1.8
1.5: (tooth)brush [bə] ~ [ba]
1.6: >[buba]
1.7: cracker [gaga] [$k_x ak_x a$]
1.8: brush [ba], grandpa [ŋəŋə]
1.9: pretty [pɪti] > [pwɪti], broke [bok'] > [buk']
three [wi], ice cream [ʔaɪti] > [ʔaɪti]
1.10: toothbrush [tušba(ɪ)š], break [bek], broke [bok']
cry, dry [daɪ], crash [daš], dress [daš] ~ [dɛš]
drink [dɪk], cracker [gago], brush [ba(ɪ)š],
three [wi]
1.11: drink [dik(ç)], pretty [bɪdi], broke [bʊt'] [bok']
three [wi], cry [dai] ~ [daɪ], train [te], dry [da(·)ɪ]
through [du] ~ [fu], crash [daš], toothbrush [tušbaš]
dress [daš], scratch [daš], streetcar [dida]
throw [do], ice cream [ʔati]

2.1: scratch [daš], crash [daš], throw away [wowe], three [wi]
2.2: crash [daʦ]

The forms for three and throw away indicate a limiting of process B, Glide Loss, although it still applies in most words.

Intervocalic r, R are usually omitted, although [w] occurs in English all right at 1.10. In all other forms Glide Loss is operating as well as R1, R2, and A. These processes (or assimilation in a few cases) give the following forms:

1.4: Marion [mɛmɛ] > [meme] at 1.5 > [mæmi] at 1.8
1.8: ironing [ʔaɪni] > [ʔaɪŋi] ~ [ʔaɪni] at 1.9
1.8: allright [ʔaɹaɪ] > [ʔa'wa] at 1.10
1.11: wheelbarrow [wibaʊ], Theresa [tita] > [dita]

4.3. Charles and Edmond Grégoire

My information on French-speaking children is from Antoine Grégoire's (1947) records of his two sons, Charles and Edmond. Concerning l's, [w] and [u] are never found as substitutes. Either l is represented as [y] or it is lost entirely. Apparently the l's in the children's model are "light". Process L1, Labiovelarization, is suppressed entirely by the children. Then Loss of Coronality (part b) and Delateralization (part b) and Strengthening give most of the correct forms.

Grégoire says (1947:317) that the consonant l began to be established at the end of the second year, in spite of the occurrence of [y] as a substitute. It was often found initially in articles, but was least sure at the end of words. Edmond says cha:-y for Charles and sa-ye for sale, and Charles says tou (or lou) for clou. At the beginning of the third year, l became an integral part of the phonology. In Grégoire's words (1947:317), their task was to "get rid of old habits of substituting [y] and to get rid of the suppression of l in consonant groups." Or, in my analysis, their task was to suppress the processes of Loss of Coronality, Delateralization, etc. Certain frequent words resist. For example, Charles says ayumette at 2.2, and soda:t at 2.3, but this becomes soldat at 2.4. Peut persists for pleut at 2.4, but pleure appears at 2.2.

Groups of consonant plus l appear early in Charles' speech. L2b and L3b are beginning to be suppressed for postconsonantal l's.

2.1: glaisse
2.3: bluwe, blu:le, blanc, but pafond for plafond until 2.7
clou, vla for voilá
2.4: mèle for merle
2.5: lwi for celui le
2.6: Chales for Charles
2.10: pleut
2.11: compliment

For Edmond:

2.2: clef is ké > kyé at 2.3 and 2.5
2.4, 2.5: plaît is pai:t
2.5: mirliton
2.6: fleur, but tablier is tabiye
2.10: perle

These forms indicate that Glide Loss is being limited for Edmond in postconsonantal position, and the words with correct l's indicate a limiting of Loss of Coronality.

For postconsonantal l's in word final position, the processes are still operating.[27] They give:

2.3: siffle > sif, couvercle > couverc
2.6: epingle > èpink

For Edmond, the processes as given also account for his treatment of preconsonantal l's.

2.5: soldat > todat, (but pal [e] tot at 2.4 is an exception)

For intervocalic l's, L2b, L3b, and Strengthening give these forms. B, Glide Loss is limited as below.

2.2: boule > bouye, sale > sa:ye, escalier > càyer

These same processes, except optional Glide Loss give the forms with initial l's, although loup has a correct l, indicating that the processes are being limited in initial position.

(B) $\begin{bmatrix} \text{glide} \\ \text{-Rnd} \end{bmatrix} \rightarrow \emptyset \; / \; \left\{ \begin{matrix} V__C \\ C__\# \\ .Co__V \end{matrix} \right\}$ optional

2.2: lion > iyon, éyon; loup
2.4: liège > yè:sse

Concerning r, Grégoire (1947:345) writes that "Charles et Edmond se montrent pendant toute la troisieme année refracteures à l'emploi normal de cette consonne." He says that the primary reason for that resistance is the weak audibility of the liquid. If it is not vibrated, it lacks clarity, and some languages or dialects abandon it precisely where Charles and Edmond have omitted it most frequently: final r in non-accented position, as in popular French (chambre > sambe at 2.5, etc.).

According to Grégoire's account of the development of the acquisition or r, Charles used the word drôle often and thus the r is conserved. At about the same time (2.5), he started using

re for several words. Its use favored keeping the initial r. Finally, a "phonological necessity" imposed the presence of r in the forms of the future: iras, fera, etc. These forms started to be used more toward the end of the third year, just when the liquid entered into usage with less irregularity. The r appeared not only between vowels (as in fesaras at 2.8 and ira at 2.9) but even in groups with an initial consonant, as in f[e]ra at 2.7, donn[e]ra at 2.8, and s[e]ras.

There are a few words in which r → w, indicating the operation of processes R1, R2, etc., and occasionally r → ə, indicating the need for R2b, but usually r → ∅ or r → y.[28] The substitution of [y] for [r] is probably because of the concave and forward tongue position characteristic of French. This seems to make the r's palatal. Therefore, Process R1, Labialization, is nearly suppressed but a process of Palatalization is operating. It would be formulated as follows:

(R'1) $$r \rightarrow [+\text{front}] \quad / \quad \left\{ \begin{matrix} \{\#, V\} __ V \\ .C __ V \end{matrix} \right\} \quad \text{optional}$$

Then there must be an additional part to R2, Deretroflextion:

(R2d) $$\begin{bmatrix} r \\ -\text{cor} \\ -\text{Rnd} \\ -\text{Bk} \\ +\text{Retr} \end{bmatrix} \rightarrow i$$

This [i] would become [y] by Process C or would be absorbed by Process B in the appropriate positions.

partie > payti,[29] encore un > a:coy-une

Many words of daily usage were deprived of r in the first half of the third year (i.e. all processes were operating), but in the last half the processes are partially suppressed, and more r's appear.

train > tain, Thérèse > tèè, armoire > am:a, tatine, kè:me

For initial r, all processes are operating in Charles' speech, although yuw for rue indicates that B, Glide Loss, is optional in initial position. Deretroflexion is suppressed in initial position at 2.7.

2.1: rue > uw ~ yuw
2.7: ruw, raser

For Edmond, all processes operate at 2.1. At 2.5 and 2.6, Deretroflexion is optional, and at 2.7 it is suppressed.

2.1: raisin > èzin, rasoir > aza
2.5: rò:be
2.6: ruw, ró:sse ~ ó:sse
2.7: renverser, regarde, etc.

For intervocalic r's, in Charles' speech all processes apply at 2.0, except that Glide Loss is optional in intervocalic position. By 2.1, Glide Loss is suppressed, and by 2.5 Deretroflexion is nearly suppressed. A few words at 2.7 indicate that the processes are still opearting optionally, but all processes are suppressed by 2.9.

2.0: couonne, couyi:r
2.1: Charette > Say-ette
2.3: Désirée > Zi:yé:y
2.4: curé, patira, baraque
2.7: sau-ais, ca-oussel, baraque
2.9: ira, courir

In Edmond's speech, the forms with intervocalic r indicate that Labialization and Palatalization are applying in competition, since some w's and some y's are found. Glide Loss is nearly suppressed, except for the forms at 2.3 and 2.4.

2.2: Charrette > gayette ~ cayette ~ cawette ~ cawyette
enco-y-une, Désirée > Zi:yéy, Dèsiyé:,giraffe > iyafe
2.3: Paris > Païs
2.4: Charrette > Saette
2.6: souris, courir, pourr:ir, déchiré, p[l]èuré

For final r's, Deretroflexion and ə-Absorption account for many of the forms in Charles' speech, but these are partially suppressed quite early, since some correct r's occur at 2.1. By 2.8, the processes are suppressed entirely.

2.1: rasoir, asa:r, fière > fè:re, odeur, acore, faire, vicaire, bwiyère, but pou, fai
2.2: bruyère, bwiyère, pleure, voiture, au revoir > avwar, but su, pa, facteu(:), fai, touzou, pou
2.3: fé:re, but tombou
2.4-2.6: pou, tard > ta:, encore > cò:, terre > tè:, bonzou, fateu, noi, bonneu, voi, su, but fière > fér, (r)asoir

In Edmond's speech, Deretroflexion and ə-Absorption operate in most words until the fifth or sixth month of the third year. At 2.6 about half the forms have final r, and at 2.7 most final r's are correct. By 2.9, the processes have been suppressed.

2.1: encò
2.2: confiture > tatu, abat-jour > à bazou, but voiture, chasseur > sassar

2.3: voir > va, encore > enco, boire > boi
2.4: zou, pou, but beurre
2.5: voitu:u, guerre > guè:, but ceinture, terre, noir
2.6: jou, sur, boire, à terre
2.7: cour, sur, but pou
2.9: fleur, pour, etc.

No substitutes (except zero) appear for preconsonantal r. Therefore, Deretroflexion and r-Absorption are operating. In some cases the preceding vowel is lengthened. The processes are beginning to be suppressed at 2.5 for Edmond and are completely suppressed by 2.7, but Charles is slower. Éternuw appears at 2.4, but it is well ahead of its time, and real suppression of Deretroflexion in preconsonantal position does not take place until 2.9 and 2.10. Edmond:

2.2: parti > ta:ti, garçon > taçon ~ daçon, Mariette > ayette, Marteau > ateau, chariot > cayòt
2.3: apò:tez, mèci, pati, rien > yien, but garçon
2.4: a:moi:, fémé:, chayòt, canet, gaçon, vète, code
2.5: zadin, sayòt, domir, but sariot, partir, mor queur
2.6: sayot, garçon ~ gaçon, fermé, farceur, jardin, carnet, corde
2.7: personne, jardin, parti, tiroir

Charles:

2.1: bardaf > badaf, domez-vous, fémez, mateur, bergère > bèzere
2.2: ja:din, dòmi:r
2.4: sò:ti, ega:dez, pòte, pati, mèci ~ mè:ci, mòceau, but éternuw
2.5: cherché > sésé, partie > pati:y, cobeaux, merle > mel
2.6: canet,[30] Irma > Ima, tournez > tounez, partira > patira
2.7: moceau, pati, zounal, renvé:sé, but cordon
2.9: partir
2.10: ga:dez, but borduw
2.11: armoire > amoire

Postconsonantal r's often do not appear at all, but are sometimes represented by [w] and sometimes by [y]. Edmond has suppressed the Labialization process for postconsonantal r's, and [y] usually appears. Charles, however, has suppressed the Palatalization process, and [w] is the usual substitute.

For Charles, Labialization, Deretroflexion and Glide Loss apply at 2.1. At 2.2, Glide Loss is being limited, and at 2.4 Deretroflexion also is slightly limited. At 2.5, all processes apply in some words, and in other words no processes apply. The processes appear to be optional at 2.6, and at 2.8. Deretroflexion has been suppressed.

2.1: bouyette, fè:r, l-a:b:icot
2.2: brouillard > bouyard, près > pè, atapé, but bwiyère
2.3: kèyon, mètte, pè
2.4: touver, kèyon, pendre, taval, dòle, coque, gand, agafe, but prener
2.5: peut-è:te, mette, tompette, dòle, apetèz-vous, but train > touwain
viendra > vindra, reluira > reluisra, grande, cême
2.6: br:un, gr:and, pruneau, prender, frère, but dòle, Kè:yon, Kè:me, chambre > sambe, pauvre > pauf
gand ~ grand, ouvi:, reluire > reluisa, viendra > vindra
2.7: doñra, frère, grant, grandez, bras, drôle, pendu, caoussel, touer, tain (later krain) ~ trwain, frwère, gwand'mamaⁿ, tremper > tremprwer
2.8: frère, drôle, fraise
2.9: François, dormira > domra, but éki:re
2.11: prendu, près, etc.

In Edmond's speech, more variation appears. All processes apply at 2.1. At 2.3 Glide Loss is slightly limited; Labialization occurs in one word; and one word occurs with a correct r, but it is exceptional. The same situation obtains until 2.7, when Deretroflexion is beginning to be limited, and some correct r's appear. By 2.10 all processes are suppressed for postconsonantal r's in Edmond's speech.

2.1: trésor > téso, croûte > coute
2.2: tom^{m}pette, crayon > ki:yon, kè:me, bosse, but train, tram > t^{ch}yin, t'in, tch'am, tchyam
2.3: train > tyin, but
kèyon, tiyon, gain, agafé:, chêvre > se:fe
bras > bwa
bretelle
2.4: train > kyin ~ tyin, trou > syou
gedin, coute, tram > kam, champe, encre > enke
2.5: kèyon, pati:y, acôche, aute
2.6: tompette, kèyon, dôle, but
train > tyin
bras > bwa
2.7: aut', gòsse, doite, temper, giyé, o:gèsse, étier, but trou > tyou (later trou), but
train > terain (later train), griyé:, prend(re), gròs, degrés > decrés, étrier
2.8: crouts, but tanquille
2.10: crouts, krand, etc.

4.4. Moscowitz

Arlene I. Moskowitz (1969, Mzb) in a study of the acquisition of English phonology, reports that in one child, Mackie, /l/ and /r/ are fairly stable, although both are quite often omitted in final position; and [w] is the most frequent substitute for both. Another child, Erica, however, is "unable to maintain her articulators in a finely adjusted position (and holds the articulators too closed, among other things)," and this leads to converting many of the l's to a j-like quality. If /l/ is not correct or does not occur in its "opener" form as [j], it is omitted (as it often is in clusters), but it is never [w]. So, Erica has suppressed Labiovelarization, and all her l's are "light." Mackie, on the other hand, has the unlimited form of Labiovelarization of l's and Labialization of r's, since [w] is the frequent substitute. Erica:

> the leaf [daɪʃjf], it's yellow [i·jɛləo], puddle [phədəl] ~ [phədəo], balloon [bəjún], eleven [i·jevɪ̌n], fly [fa·i] ~ [fiə̯·j], playground [phe·jgɹəə̯nd], Arlene [aɹjɪ̌·n], poor Leslie [phɔɹ·esjʃj]

The r's in playground, Arlene, poor Leslie above are correct, as they are in frog [fɹa^·g], cars [kha·ɹs·], and beer [bʃə̯ɹ]

5. Summary of Processes and Their Limitations; Conclusion

L1. Labiovelarization

$$l \rightarrow \begin{bmatrix} +\text{Rnd} \\ +\text{velar} \end{bmatrix}$$

This is limited to

$$l \rightarrow \begin{bmatrix} +\text{Rnd} \\ +\text{velar} \end{bmatrix} \quad / \ [\ ]\ __$$

by Daniel, Suzanne, Eleni, Jennifer, Joan (except that some intervocalic l's are excluded), and Hildegard (except that Labiovelarization is optional for her in intervocalic and word final positions).

This process is entirely suppressed for Erica, and Charles and Edmond Grégoire; Mackie has it in its unlimited form.

L2. Loss of Coronality

$$[+\text{lateral}] \rightarrow [-\text{coronal}]$$

i.e. a) $\begin{bmatrix} +\text{velar} \\ +\text{Rnd} \end{bmatrix}^{1^{w}} \rightarrow \underset{\wedge}{u}^{1}$

Jennifer limits this part to

$$1^{w} \rightarrow \underset{\wedge}{u}^{1} \quad / \quad \left\{ \begin{matrix} f __ V \\ __ \left\{ \begin{matrix} C \\ \# \end{matrix} \right\} \end{matrix} \right\}$$

b) $\begin{bmatrix} -\text{velar} \\ -\text{Rnd} \end{bmatrix}^{1} \rightarrow \underset{\wedge}{i}^{1}$

Daniel limits this at 1.6-1.7 to

$$\begin{bmatrix} -\text{velar} \\ -\text{Rnd} \end{bmatrix}^{1} \rightarrow [-\text{coronal}] \quad / \quad __ \begin{bmatrix} +\text{High} \\ V \end{bmatrix}$$

L3. Delateralization

$$\begin{bmatrix} -\text{cor} \\ -\text{son} \\ \pm\text{velar} \end{bmatrix} \rightarrow [-\text{lateral}]$$

i.e. a) $\underset{\wedge}{u}^{1}$ $\begin{bmatrix} \text{son} \\ +\text{velar} \end{bmatrix}$ $\rightarrow$ $\underset{\wedge}{u}$ $[-\text{lateral}]$

b) $\underset{\wedge}{i}^{1}$ $\begin{bmatrix} \text{son} \\ -\text{velar} \end{bmatrix}$ $\rightarrow$ $\underset{\wedge}{l}$ $[-\text{lateral}]$

The children limit and suppress these earlier in some positions than in others.

R1. Labialization

$$\begin{bmatrix} r \\ \pm\text{syll} \end{bmatrix} \rightarrow [+\text{Rnd}]$$

This is limited to

$$\begin{bmatrix} r \\ \pm\text{syll} \end{bmatrix} \rightarrow [+\text{Rnd}] \quad / \quad \left\{ \begin{matrix} .\text{Co}__ \\ \underline{+\text{stress}} \\ V__V \end{matrix} \right\}$$

by Daniel, Suzanne, Eleni, Melissa, Jennifer (although no examples of intervocalic r appear), and Hildegard (although it is optional for initial r's).

Mackie has R1 in its unlimited form. For Joan it is slightly limited in final position and does not apply intervocalically. Edmond and Charles have nearly suppressed R1.

R2. Deretroflexion

sonorant → -R

i.e. a) r, w → ɹ̠ / [-coronal, +Rnd, +Bk, +Retr., -stress]

b) r → ə / [-cor, -Rnd, +Bk, +Retr., -stress]

c) ɾ́, w → ɔ́ə̯ / [-cor, +Rnd, +Bk, +Retr, +stress]

The subparts of this process become optional or are suppressed at different times in the different positions in words.

A. Raising

[+voc, +Rnd, +Bk] → [+High]

i.e. a) o̞ → u̯

b) o̞ə̯ → u̯ə̯

No specific limitations are found.

B. Glide Loss

[Glide, ±Rnd] → ∅

Dnaiel at 1.6-1.7 limited this as follows:

[+Rnd, glide] → ∅ / {V__C, .C__V} a) b)

Part b was limited right away

[±Rnd, glide] → ∅ / {V__C, . [-cor, cons]} a) b)

At 2.5 part a was limited

$$\begin{bmatrix}+\text{Rnd}\\ \text{glide}\end{bmatrix} \rightarrow \emptyset \;/\; \left\{\begin{array}{ll}\begin{bmatrix}+\text{High}\\ +\text{Bk}\\ \text{V}\end{bmatrix} & __\text{C} \quad \text{a)}\\ \\ \begin{bmatrix}-\text{cor}\\ \text{cons}\end{bmatrix} & __\text{V} \quad \text{b)}\end{array}\right.$$

Suzanne has this same limitation of (a) at 2.10, as did Joan at 1.1 (except that a consonant does not have to follow).

Eleni, Jennifer, and Joan limited it to

$$\begin{bmatrix}+\text{Rnd}\\ \text{glide}\end{bmatrix} \rightarrow \emptyset \;/\; \left\{\begin{array}{l}\text{V}__\left\{\begin{array}{l}\text{C}\\ \#\end{array}\right\}\\ \\ (.)\text{C}__\text{V}\end{array}\right.$$

Hildegard limited B to [+Round] glides at 1.5, as follows:

$$\begin{bmatrix}\text{glide}\\ +\text{Rnd}\end{bmatrix} \rightarrow \emptyset \;/\; [\ ]__$$

then at 1.8:

$$\begin{bmatrix}\text{glide}\\ +\text{Rnd}\end{bmatrix} \rightarrow \emptyset \;/\; \left\{\begin{array}{l}[\ ]\ _\text{V}\\ \left\{\begin{array}{l}\text{ɔ}\\ \text{o}\end{array}\right\}\ _\\ (\text{a}\ __)\end{array}\right.$$

The Grégoires limited B to [-Round] glides:

$$\begin{bmatrix}\text{glide}\\ -\text{Rnd}\end{bmatrix} \rightarrow \emptyset \;/\; \left\{\begin{array}{l}(.\text{C}_{\text{o}}\ _\text{V})\\ \text{C}\ _\ \#\\ \text{V}\ _\ \text{C}\end{array}\right. \quad \text{optional}$$

C. Strengthening

$$\text{glide} \rightarrow [\text{-vocalic}] \;/\; \left\{\begin{array}{l}.(\text{C})\\ \text{V}\end{array}\right\}\ _\ \text{V} \quad \begin{array}{l}\text{a)}\\ \text{b)}\end{array}$$

i.e. i̯ → y
u̯ → w

D. ə-Absorption

$$\text{ə} \rightarrow \emptyset \quad / \quad [\text{vocalic}]\ __$$

Daniel and Melissa have this process in a more limited form:

$$\text{ə} \rightarrow \emptyset \quad / \quad \begin{bmatrix}+\text{voc}\\ +\text{Bk}\end{bmatrix}\ __$$

Daniel limits it further to

$$\text{ə} \rightarrow \emptyset \; / \; \begin{bmatrix} +\text{Low} \\ +\text{Bk} \\ +\text{Rnd} \\ \text{V} \end{bmatrix} \; __$$

Eleni has it in the form

$$\text{ə} \rightarrow \emptyset \; / \; \begin{bmatrix} +\text{Low} \\ +\text{Bk} \\ \text{V} \end{bmatrix} \; __$$

and ə-Absorption is optional for her after all other vowels.

Hildegard has it in its unlimited form, although it is optional after 1.10.

5.1. Special Processes

R'1. Palatalization

$$\text{r} \rightarrow [+\text{front}] \; \left\{ \begin{matrix} \left\{ \begin{matrix} \# \\ \text{V} \end{matrix} \right\} _\text{V} \\ (.\text{C}_\text{V}) \end{matrix} \right\} \text{ optional}$$

Edmond and Charles have this process. Joan has the form:

$$\text{r} \rightarrow [+\text{front}] \; / \; \text{V} _ \text{V}$$

before 1.11. Hildegard, at early stages, has the limited form

$$\text{r} \rightarrow [+\text{front}] \; / \; \# \; _ \text{V}$$

R2d

$$\overset{\text{r}}{\begin{bmatrix} -\text{cor} \\ -\text{Rnd} \\ -\text{Bk} \\ +\text{Retr} \end{bmatrix}} \rightarrow \text{i}$$

Joan and Hildegard have this process early, and Charles and Edmond have it at all stages.

$$\text{a)} \;\; \text{y (or j)} \rightarrow [\check{\text{z}}] \rightarrow \left\{ \begin{matrix} \text{z} \\ \text{h} \end{matrix} \right\}$$

Joan has the first part of this process so that j → z. Hildegard has the second part at early stages, but it is optional (j → h / # __)

b) $\begin{bmatrix} l \\ -\text{Rnd} \\ -\text{Velar} \end{bmatrix} \rightarrow n$

Only Emily has this late change.

c) Vowel Adjustment

1) $\text{ə} \rightarrow \left\{ \begin{matrix} i \\ \text{I} \\ a \end{matrix} \right\}$ optional

Hildegard has these changes.

d) ə → a

Joan has this late process.

5.2. Conclusion

Although the exact form of the above processes varies from child to child, it can be seen that these processes of Labio-velarization of l's, Labialization of r's, etc., do account for most of the substitutions encountered in the speech of the children investigated. Thus the hypotheses made at the outset of the study have been verified: 1) A few basic processes seem to be taking place in the children's acquisition of liquids. 2) These processes are gradually limited and suppressed as acquisition proceeds. 3) Changes taking place in French and German children are slightly different (i.e. the processes are being suppressed differently according to the types of liquids found in the language). It will be shown in Appendix B that the fourth hypothesis, concerning historical change and dialectal variation, has also been verified.

In conclusion, it appears that the acquisition of at least this one segment of phonology, the liquids, can be explained quite well by the model which says that a number of innate processes are gradually limited and suppressed as acquisition progresses.

Appendix A

Processes in Their Strongest Forms

l

L1. Labiovelarization

$$l \rightarrow \begin{bmatrix} +\text{Rnd} \\ +\text{velar} \end{bmatrix}$$

L2. Loss of Coronality

[+lateral] → [-coronal]

i.e. a) $\overset{w}{l} \begin{bmatrix} +\text{velar} \\ +\text{Rnd} \end{bmatrix} \rightarrow \underset{\sim}{u}^{l}$

b) $\overset{}{l} \begin{bmatrix} -\text{velar} \\ -\text{Rnd} \end{bmatrix} \rightarrow \underset{\wedge}{i}^{l}$

L3. Delateralization

$$\begin{bmatrix} -\text{cor} \\ +\text{son} \\ \pm\text{velar} \end{bmatrix} \rightarrow [-\text{lateral}]$$

i.e. a) $\underset{\sim}{u}^{l} \rightarrow \underset{\sim}{u}$

$\begin{bmatrix} \text{son} \\ +\text{velar} \end{bmatrix} \rightarrow [-\text{lateral}]$

b) $\underset{\sim}{i}^{l} \rightarrow \underset{\wedge}{i}$

$\begin{bmatrix} \text{son} \\ -\text{velar} \end{bmatrix} \rightarrow [-\text{lateral}]$

A. Raising

$$\begin{bmatrix} +\text{voc} \\ +\text{Rnd} \\ +\text{Bk} \end{bmatrix} \rightarrow [\text{High}]$$

i.e. a) $\underset{\sim}{o} \rightarrow \underset{\sim}{u}$

b) $\underset{\sim}{o}^{\vartheta} \rightarrow \underset{\sim}{u}^{\vartheta}$

B. Glide Loss

$$\begin{bmatrix} \text{glide} \\ \pm\text{Rnd} \end{bmatrix} \rightarrow \emptyset$$

r

R1. Labialization

$$\begin{bmatrix} r \\ \pm\text{syll} \end{bmatrix} \rightarrow [+\text{Rnd}]$$

R2. Deretroflexion

Sonorant → -R

i.e. a) b) c)

$\overset{r}{w} \begin{bmatrix} -\text{cor} \\ +\text{Rnd} \\ +\text{Bk} \\ +\text{Retr.} \\ -\text{stress} \end{bmatrix} \downarrow \underset{\sim}{o}$

$\overset{r}{} \begin{bmatrix} -\text{cor} \\ -\text{Rnd} \\ +\text{Bk} \\ +\text{Retr.} \\ -\text{stress} \end{bmatrix} \downarrow \vartheta$

$\overset{r}{w} \begin{bmatrix} -\text{cor} \\ +\text{Rnd} \\ +\text{Bk} \\ +\text{Retr.} \\ +\text{stress} \end{bmatrix} \downarrow \acute{o}_{\wedge}^{\vartheta}$

C. Strengthening

$$\text{glide} \rightarrow [\text{-vocalic}] \; / \; \begin{Bmatrix} .(C) \\ V \end{Bmatrix} __ V \quad \begin{matrix} a) \\ b) \end{matrix}$$

i.e. $\underset{\wedge}{i} \rightarrow y$

$\underset{\wedge}{u} \rightarrow w$

D. $\underset{\wedge}{\text{ə}}$-Absorption

$$\underset{\wedge}{\text{ə}} \rightarrow \emptyset \; / \; [\text{+vocalic}] __$$

Special Processes of Limited Application

R'1. Palatalization of r

$$r \rightarrow [\text{+front}] \; / \; \begin{Bmatrix} \begin{Bmatrix} \# \\ V \end{Bmatrix} __ V \\ (.C __ V) \end{Bmatrix} \quad \text{optional}$$

R2d. Deretroflexion of palatal r

$$\overset{r}{\begin{bmatrix} \text{-cor} \\ \text{-Rnd} \\ \text{-Bk} \\ \text{+Retr.} \end{bmatrix}} \rightarrow i$$

a) y (or j) $\rightarrow (\check{z}) \rightarrow \begin{Bmatrix} z \\ h \end{Bmatrix}$

b) $\overset{l}{\begin{bmatrix} \text{-Rnd} \\ \text{-velar} \end{bmatrix}} \rightarrow n$

c) Vowel adjustment

1) $\text{ə} \rightarrow \begin{Bmatrix} i \\ \text{ɪ} \\ a \end{Bmatrix}$ optional

2) $\begin{Bmatrix} \text{ɪ} \\ V \end{Bmatrix} \rightarrow \text{ə} \rightarrow a$ optional

d) $\text{ə} \rightarrow a$

Appendix B

Brief Survey of Similar Processes in Synchronic Alternation, Historical Change, and Dialectal Variation

Most of the processes found to be operating in the speech of the children do have parallels in historical change or dialectal variation. The major processes are found in several languages, and the less important processes have fewer parallels in historical change.

1. Processes affecting l

1.1. Labial Substitutes

Passy (1890:156, 157, 224) writes that a slight exaggeration of "grave l" (velar) gives [lɣ] and if this is then joined by labial action, [lʷ] results, "as we sometimes find in English." He says that this [lʷ] is very common in Slavic languages, and that:

> pour un son somme [lʷ], la modification labiovélaire n'est que l'accessoire; mais si elle est très forte, elle peut finir par être l'essentiel, et alors on la conserve seule sans articuler de [l]; ce qui donne [w] ou [u]. C'est ainsi que l'anglais rook... devient wuk.

Similarly, Grammont (1950:278) writes that, if a velar, especially at the end of a syllable, loses its "glissement latéral," a w is substituted naturally for it. Grammont (1950:207) explains the velarization of l between a vowel and a consonant as follows:

> The preceding vowel tends to increase the aperture of the l, and "d'autre part la consonne appuyée qui suit tendant à faire anticiper ses mouvements articulatoires, la pointe de la langue perd la fermeté de son point d'appui; la langue se détend et par suite sa partie postérieure remonte vers le voûte palatine. Le glissement latéral est donc reporté plus en arrière: c'est l'l vélaire."

That state is generally that of Latin. In French the evolution has continued, and the point of the tongue has definitely lost contact, The velar l has become [u] (i.e. *chevals > chevaus, etc.). The phase [u] has been preceded by a phase [u*], at the moment when the point of the tongue was only on the verge of losing

contact. That phase is conserved in "roumanche:" kau^{ł}, au^{ł}, au'ter. The English of the 16th century gives a further example: all, salt, talk were pronounced [ɑul], [sɑult], [tɑulk].

C.-J. Bailey (1969:270) discussed [ɨ] in American English dialects. He says that [ɨ] has a [ɯ] or [ʊ] quality and is articulated with the dorsum of the tongue against the teeth on one side of the mouth. Examples from Southern States English show the [u] vowel as in [bɒ^{U}ɨ] for ball.

Wise (1957) also discusses the velarization of postvocalic l's in English. He says that "drawl dialects" draw out the l until it forms another syllable, and [ə] intrudes to augment the syllable. Fool becomes [fuəɨ], and in Eastern American call is [kɔəɨ]. In Southern forms the l drops, but velarization (and labialization) of the vowel is retained, and we find milk [mɪok], kill [kɪo], built [bɪot]. The same process produced a vowel of a different height in Scottish English. Tollbooth is [tʌ^{ʊ}buθ], ball is [bʌ^{ʊ}]. The velarized vowel is dropped regularly after [a] in Scottish English, and scald is [skad], all [a], false [fas], awful [afu]. In Southern American and Negro dialects, the velarized vowel disappears in words like twelve [twəv], million [mijən]. This also happens in General American before j, r, and w, and volume is [vajɛm], already is [arɛdi].

1.2. Palatal Substitutes

Changes of l to [y] (or [j]) are common in the literature on historical change. Usually the change takes place via [l']. Grammont (1950: 81, 208) writes that 'palatalized' l's are very frequent. They are characterized by a large extent of the region of contact of the tongue, but vary greatly according to language and positions of the tongue. Grammont explains how an [l] can change to [i] in postconsonantal position, as in Italian chiave from claue, pieno from plenu, bianco from blancu, etc. He says (1950: 268) that the initial phenomenon is always the same, "affaiblissement par la voyelle de la position spécifique de la pointe de la langue," which takes a position more favorable to the following consonant.

> Dès lors ce n'est plus la pointe qui s'élève vers le palais, mais la partie antérieure du dos de la langue; c'est à peu près la position de [l'], à laquelle on aboutit instantanément.

In some regions [l'] is still preserved, for example in the mountainous dialects of Fribourg, and in many dialects [l] is palatalized only after palatals: chiang, but plin, bland.

Passy (1890:145) also gives the above example of ordinary l → [j] or [i] in Italian, and he says that it probably happened by the intermediary of [ʎ] or [l^{j}], but that, judging from the pronunciation of children, it could have been direct. He reports that the reinforcement of a transitory sound in [j] takes place after a palatal liquid [ʎ], which thus becomes [l+j]. This

happens in northern France and results in [bri·ʃje], [muʃje] for [briʎe], [muʎe]. In Swedish l, → j, probably by way of [ʎ].

Passy (1890:94, 158) also tells how laterals can become vowels if the passage of air is enlarged. When the passage is enlarged, the rest of the tongue occupies a determined position, and one hears the vowel corresponding to the last position modified by the particular position of the point of the tongue. Thus French acute l may become [j] or [i]:

$$[l^j] \rightarrow [ʎ] \rightarrow [j] \text{ or } [i]$$

Jakobson (1968:17) mentions that l (and r) change to [j] in the Russian dialect of Lower Kolyma, and also in the "love language" of Russian peasant women in Northeast Siberia.

Collinder (1965:88) reports that Mordvin intervocalic l has become palatal before front vowels:

$$*l \rightarrow l' \; / __ \; \begin{bmatrix} +\text{voc} \\ +\text{front} \end{bmatrix}.$$

Collinder also says (1965:80) that in some of the Uralic languages reconstructed *l's developed into [j], before both front and back vowels.

Passy, who in 1890 was saying that "changes come from children" gives one example concerning l's (1890:233).

> Le changement d'l en l mouillé après une consonne, qui s'est accompli dans tant de dialectes romans, n'est qu'une prononciation enfantine rectifiée, prononciation qui aujourd'hui encore naît brusquement sous nous yeux, tels parents disant très nettement fleur, blanche, et leur enfant non moins nettement fleur, bllanche (j pour l mouillé.)

1.3. Nasal Substitute

The change of [l] to [n] which appeared in Emily Salus' speech is found less frequently in the data on historical change. However, Grammont (1950:208) does mention that in certain places in the interior of the island of Sicily l has become n before dentals. The anterior part of the tongue has taken in advance exactly the position required for the dental, and the l "n'a eu d'autre ressource pour sortir en glissement que de recourir à l'abaissement du voile du palais." Thus we find antru, santu, punsa, etc.

Often l → n is cited as a sort of assimilation (e.g. lincel → nincel in "le trécorois") or a dissimilation (e.g. Vulgar Latin cuntellu from cultellu) (Grammont 1950:278).

Thai has no syllable final l or r, and when these are introduced in loan words, n is substituted for them. This is also frequent in American Indian languages, e.g. Biloxi changes l from loan words to [n], and in Nootka, l has everywhere become [n]. In addition, [n] is sometimes substituted for liquids in "consonant symbolism" used in some Indian languages of the Northwest.[31]

Juang, a Munda language, also has undergone a process whereby l became [n] in certain positions so that buffalo, which is bɔŋtɛl in Sora, and bɔŋtel in Kharia, is bɔŋten in Juang, and girl, which is ɔnsɛl in Sora and konsel in Kharia is bɔŋcen in Juang (Pinnow 1960).

1.4. Other Substitutes

In support of our claim that the substitution of z for light l in Joan Velten's speech involves several processes, there appear to be no examples of such an alternation or change in adult languages.

The confusion of l and h is mentioned in Grammont (1950:205). He writes that h has a

> point d'articulation vague sur la moitié antérieure du palais, du sommet de la voûte aux dents. L'h est un phonème à glissement articulé dans la meme région. La confusion acoustique entre les deux est facile; la différence articulatoire est minime, l'h en question étant une sorte d'l articulé avec la pointe de la langue vers le bas.

2. Processes Affecting r's.

2.1. Labial Substitutes

Passy (1890:156) discusses the labiovelarization of r's.

> cette concordance des actions labiale et vélaire... Ainsi le [ɹ] anglais se prononce souvent [ɹʷ] Il n'est pas rare que ce [ɹ] se transforme en [w] (surtout devant les voyelles vélaires): rook [wuk], horses [ɑɹʷsɨz].

If a French velar r is prolonged and accompanied by labial action [ʁʷ] results (Passy 1890:48, 147, 156). In Parisian French [ʁ] tends to be velarized and changed to [qˠ], which can then become [w]:

$$[q^{\gamma}] \rightarrow [q^{\nu}] \rightarrow [\nu^{q}] \rightarrow [w]$$

In some French dialects r becomes a voiceless velar fricative

and then eventually [w]. Similarly, German uvular r, if rounded, may become [w] by way of a velar spirant.

2.2. r → ə (or a)

About the change of r to [ə], Grammont (1950:77) says:

> Quand la fricative est un sonore, si l'aperture augmente et que la pression diminue légèrement, on n'entend plus que les vibrations laryngiennes, à moins que la disposition des organes ne fournisse un résonateur propre à l'émission d'une voyelle. Ainsi en anglais dans certaines positions particulièrement à la finale, l'r devient [ə]: dear [dɪə] father [faðə]. (Cette voyelle [ə], articulée un peu en avant du sommet de la voûte palatine, est une sorte d'a dans divers dialectes: dans certains parlers d'Allemagne du Nord der Vater → [dafata], der Berger → [dabaga] c'est bien un a mas ce n'est pas l'a ordinaire de ces parlers; c'est un a qui a le timbre de l'r qu'il remplace.

Passy (1890:94) tells how all fricatives (including r) can become vowels when the passage is enlarged. The tongue occupies a determined position, and one hears the vowel of the past position, modified by the particular position of the point of the tongue. Thus we get [iʲ],[oᵝ],[rᵊ], etc. These sounds do exist in some languages, for example [ɑʲɹ],[ɔʲɾ] in English dark and lord and [rʲ] in Russian.

There are many such examples from contemporary dialects in C.-J. Bailey (1969:250-253). He says that [ɹ̩] before consonants and word boundaries loses its retroflexion and becomes [ə]. One may hear seer as [sɪ-ə] or [seᵊ:], ewer [yu-ə], cart [kʰɑ(ə):t], horse [hɔ(ə):s], were [wɛᵊ:] (in British English). In the deep South boor, bore, pure, four, etc., have [oᵊ:] or [ɯᵊ:]. In short, tort [ɔ(ə):] is often heard. Iron in some dialects may be [ɑᵊ(:)n].

2.3. Loss of r

Loss of intervocalic r, as found in some children, is reported in Vulgar Castilian Spanish (Castro 1924:12). Quiero is [quiɔ́] fueras [fuás], etc.; and in Andalusia r is lost in traélo, llaválo, for traerlo, llevarlo.

Jakobson (1968:14) mentions the loss of r before consonants in Russian children (with a lengthening of the vowel), so that marka "mark" is [ma:ka].

2.4. Palatal Substitutes

Grammont reports (1950:209) that in Andalusia r → y and from there becomes [i], the second element of a diphthong:

porquero → poiquero, largo → laigo. He presumes that there would be an intermediate step of palatalized r [ɹʲ].

As mentioned previously r (and l) change to [j] in the Russian dialect of Lower Kolyma, and in the "sweet talk" of Russian peasant women. Jakobson (1968:17) also mentions that this change occurs in Grammont's 2-year-old son, who took the pronunciation from his younger sister and generalized it through his whole vocabulary.

2.5. Other Substitutes.

There are examples of the change of r → z in the literature, although the opposite change of z → r (rhotacism) as in Latin in intervocalic position, or in the Germanic languages, is more common.[33] Passy (1890:147) mentions the change of r → s in French, as in chaire → chaise. He supposes [ɹʲ] as an intermediate step, which still exists in some areas. Grammont's explanation (1950:74) of the change of r to z is as follows:

> Si les organes ne sont pas assez rapprochés pour que le tremblotement se produise, l'air s'écoule d'une manière égale entre ces organes et les r qui en résultent sont bien alors des liquides et des spirantes. C'est à tel point qu'il leur arrive de se confondre acoustiquement avec d'autres liquides ou d'autres spirantes. Ainsi l'r alvéolaire sans battements se confond aisément avec une certaine nuance de z: roussillonnais sastre < *saztre < sart(o)re.

In Turkic reconstructed *r̥ (intervocalic) developed into z (Poppe 1965:197). Manchu iri, Mongolian ir, Chuvash yer, ancient Turkic iz "trace."

The minor change of r → h which appeared in Hildegard Leopold's speech has a few parallels in historical change and dialectal variation. Grammont (1950:278) writes that posterior aspiration is a very satisfying replacement of a velar or pharyngeal r; thus Arabic sarsá "cacher" arises from sarsar. Grammont says that any r whatever can:

> aboutir par dissimilation à une aspiration. Se cette aspiration est mal caractérisée ou si le système phonique n'en comporte pas, c'est l'amuissement, le résidu de l'r dissimilé n'ayant pas pu prendre corps sous forme d'un autre phonème existant.

Castro (1924:12) reports a change of r to h in the Andalusia dialect of Spanish: carne > cahne, virgen > vihen, etc.

Footnotes

1. "Frequency" may not be the best term to use here, but it indicates simply that the number of forms in which a process is applying is becoming progressively smaller. The process is still optional, but it is applying to fewer forms.

2. At this stage (2.11) horses is [hoə˞sɨz], with [o̞ə̯] like Daniel had. The r off-glide may indicate that we need another rule, between Labialization and Reretroflexion, parallel to L2, Loss of Coronality. This would give a stage like [o̞ə˞], etc., parallel to [ɥˈ] [lˈ].

3. Suzanne inserts epenthetic [ə] here, as Daniel did.

4. Daniel occurs once at this stage as [dǽnəl], which is far ahead of its time, perhaps because it is such a frequent word.

5. [wáɻn̩] also appears for this word, indicating the unlimited form of Labiovelarization, but it is the only such form found for Eleni.

6. It is impossible to tell what is happening with intervocalic l's, since telephone is [dɛ́fon], color [kʌ́da], dollie [dɔ́dɨ].

7. Light occurs once as [zá ɻt]. This is interesting in view of later data on Joan Velten.

8. It should be noted here that since Melissa's model is a Northeast r-less dialect, probably R2b and D will never be suppressed in final or preconsonantal position.

9. For the word for animals we need a rule lowering [u] to [o] in this particular environment.

10. All postconsonantal l's were unrepresented in Jennifer's speech a year earlier. I do not know why Loss of Coronality has been so strangely limited at this stage.

11. Cry occurs at this stage as [kwáɪ], indicating that B, Glide Loss, is being limited.

12. There is independent evidence for this process since the only word with an initial y in the model has a [z] in Joan's speech: yard [za·d].

13. Lunch also occurs as [nʌts] but this is explainable by assimilation, as are [bap] for lamb and [nan] for lion.

14. Since Velten is writing phonemically, he uses w for the [u] in word final position after a vowel. I am treating them as equivalent in this position.

15. Joan often lengthens vowels when the glide is lost, both for l's and r's.

16. Postconsonantal r's in French words are treated the same at this stage, e.g. [dus] is found for gris.

17. At 1.11 to 2.3 French uvular r is [z] as in Raoul [zaw] Montreal [mazuaˈ] (from [mɔ̃ʀeɑˈl]). At 2.0 prends garde is [zadad]. English pr would be a simple labial stop at this stage. Gaberell Drachman says that the [z] for r is due to the fact that the tongue tip is down for French, and the child lacks tongue tip control at this early stage.

18. For Karla, Hildegard's younger sister, [j] was a less common substitute, although [jək] was found for lake at 1.10.

19. Liebling is [wiţi] at 1.11. Leopold interprets this not as a real substitute, but as a blend with Fritzchen or sweetheart. Karla has [ipi] ~ [ipţi] at 1.11, with omission of the l.

20. Leopold quotes other studies in which [ɪ] is found for German l. For example, in footnote 35 (Leopold 1939:26) he quotes Ronjat, who says that Ball may be [bay].

21. Leopold (1939:65) says that Karla's regular substitute was [u] at 1.10 and 1.11 in apple, purple, [ɔ] in bicycle. People was [pipi] at 1.10. She omitted English and German l in all, call, nail, bell, etc.

22. In footnote 175 Leopold (1939:70) says that Kenyon (p. 221) gives [ʋ] for l, giving [mɪʋk] as the common form for milk, but he also mentions that [mɪək] is found.

23. Karla also had sl → j (Leopold 1947:67).

24. Although I did not find such variation in my work, it is evidently not uncommon. In footnote 186, Leopold says that Holmes (p. 221) notes that r → ə in bear from 1.7 to 1.11, but Holmes gives [a] as another substitute. Also Karla has [ɪ] occasionally as in [hɛɪ] for hair at 1.10.

25. Karla (Leopold 1939:136) at 1.10 had [hoət] for hurt, which is what we would expect to get by processes R1, R2c, and A.

26. [pyţi] also appears occasionally at 1.4 and 1.5. Similarly, Karla has [pyi] at 0.9 and [pyţi] at 0.11. These forms can be explained by optional Palatalization of r and Deretroflexion. The Palatalization process is given in Appendix A.

27. Since postconsonantal word final l is usually unrepresented in popular French, these processes may never be suppressed for l's in that position, although the usual explanation is that such final l's are devoiced and then lost (e.g. tabl → tabl̥ → tab).

28. Occasionally r → l as in brûle > bluwe at 2.1 and blu:e at 2.5.

29. pa:yţi is a variant. Early attempts at r sometimes result in such an elongation of the preceding vowel, regardez > a:dez.

30. Grégoire (1947:305) says that when asked if he said canet, Charles responded, "No, ca-net" (with a slight pause).

31. Consonant symbolism is a deliberate change of sounds, frequent for some kind of diminutive or derogatory speech, or when speaking to children (Mary R. Haas, personal communication).

32. Grammont (1950:293) mentions a change of z → i before a sonorant in "roussillonnais" (e.g. *azbre > áibre, etc.).

33. Arnold M. Zwicky (personal communication) says that we should not discount the possibility that an apparent change r → z is really the reappearance of an underlying z.

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Creative Errors in the Writing of Deaf Children[1]

Jonnie E. Geis

1. The Problem.

Deaf children face a problem in language acquisition that is shared by no other population. It seems reasonable to assume that they receive little, if any, linguistic input before beginning their formal education, generally at age five or six, and that after that point their linguistic input is primarily limited to classroom and reading materials that can be presented visually. As a result, the language acquisition of these children is greatly delayed, and few of them ever produce and understand all of the syntactic constructions and processes of adult English.

In their writing, deaf children produce a number of grammatical constructions that differ significantly from any constructions of adult English. Since the children can be assumed not to have had models for the production of these constructions, proponents of the innateness hypothesis must assume them to be creative errors. By a "creative error" I mean the incorrect, though consistent, use of a linguistic structure to represent a certain meaning. I will describe and attempt to characterize, in terms of syntactic rules, the most frequent creative errors that have been found to occur in the writings of these children in two areas of English syntax, conjunction and relativization, and I will investigate the implications of these errors for the theory of language acquisition.

2. The Writing Samples

The data used in this study were taken from writing samples collected as part of a five-year Office of Education project and are currently being analyzed syntactically as part of a second five-year project.[2] The results I will report came after a year of preliminary linguistic analysis of samples from nearly five hundred subjects ages ten through eighteen. The samples were collected over a five-year period in state schools for the deaf in all geographical areas of the country (each child writing one sample every year) and were elicited with a series of pictures as stimuli. The creative errors described below were found in the samples from a large percentage of the population and were not confined to any area of the country or any one type of school (residential, day, public, private, etc.). Thus the errors seem typical of the linguistic behavior of the population of deaf children in this country.

3. Conjunction Errors

All but a few of the subjects used conjoined sentences and conjoined phrases with and in their samples. Conjoined subjects appeared earliest, in samples written by ten-year-olds, while the other types of conjunction (conjoined sentences, verb phrases, and direct objects) appeared later, at ages twelve or thirteen for most of the subjects. These are the types of grammatical English conjoined structures that appeared most frequently. Sentences (1)-(4) are examples.

(1) The boy and the girl went to the store.
(2) The boy bought some lemons, and the girl squeezed them.
(3) The boy bought some lemons and made lemonade.
(4) The boy bought some lemons and a pitcher.

There is one other type of conjoined structure that is quite frequent in adult English--conjoined verbs sharing a subject and an object, as in (5).

(5) The boy cut and squeezed the lemons.

The fact that sentences of this sort do not appear in the samples presents a significant deviation of the subjects' conjunction from that of adult Engish, since conjoined verbs can be analyzed as produced by the same Conjunction Reduction schema as the conjoined phrases in (1), (3), and (4).3 The absence of sentences like (5) could be treated as an accidental gap in the data; however, the high frequency of types (1)-(4) casts doubt on such a treatment, as does the fact that all of the subjects wrote descriptions of a picture sequence for which sentence (5) would be quite appropriate.

Even more significant than the absence of type (5) is the fact that there are two types of conjoined sentences which appear very frequently in the samples starting at ages twelve and thirteen that are not acceptable in adult English and for which the children cannot be claimed to have had models. Sentences (6) and (7) are examples of these.

(6) The boy bought some lemons and the girl washed.
(7) The boy threw the ball and bounced over the fence.

The meanings of such sentences are clear from the contexts of the samples and from the pictures the children were asked to describe; (6) means that the girl washed the lemons, while (7) means that the ball bounced over the fence.

It should be pointed out that conjunction is the method of sentence combination most often used by the subjects and that sentences like (6) and (7) appeared in the writing of at least half of the subjects. What is needed is an explanation of these

differences between adult English conjunction and deaf children's conjunction. Why are (6) and (7), but not (5) used by deaf children? Let us look at the conditions under which phrases conjoined with and can be formed in adult English and see at what points (6) and (7) violate these conditions. I will assume that all the sentences above containing conjoined phrases, both for adult English and for the written language of the subjects, are to be derived from full conjoined sentences by some syntactic reduction process. For example, a sentence with a conjoined object, like (4) above, will be assumed to be derived from the same underlying structure as (8).

(8) The boy bought some lemons, and the boy bought a pitcher.

There are two conditions which a full conjoined sentence must meet if Conjunction Reduction is to apply to it, conditions A and B; and there is one condition which the reduced sentence resulting from Conjunction Reduction must meet, condition C.

Condition A: The identical elements in the two conjoined sentences must be in the same position and have the same constituency--i.e., both must be subjects, or both must be verb phrases, etc.

Condition B: The identical elements must be positioned at one or the other end of their respective sentences.[4]

Condition C: The element in the derived sentence which corresponds to the identical elements in the source sentence must be positioned at one or the other end of the derived sentence.

Condition C describes the effects of the schema, representing the fact that a copy of the identical element is made at the beginning or end of the sentence, depending on the position of the identical elements in the source sentence. The derived constituent structure of the sentences will not be considered, since there is no way to determine the constituent structure of the sentences in the samples.

These conditions are satisfied by all of sentences (1), (3) - (5), and the conjoined sentences assumed to underlie them, but they are not satisfied by sentences (6) and (7). Sentence (6) violates condition C, while (7) violates conditions A and C. Notice that (9) is the source sentence for (6), repeated below, and that (10) is the source sentence for (7), also repeated. The identical elements are underlined.

(9) The boy bought <u>some lemons</u>, and the girl washed <u>the lemons</u>.
(6) The boy bought <u>some lemons</u>, and the girl washed.

(10) The boy threw the ball, and the ball bounced over the fence.
(7') The boy threw the ball and bounced over the fence.

From this discussion it seems that the English Conjunction Reduction schema cannot properly describe the abbreviations of conjoined sentences that are allowed by deaf children. It predicts the appearance of one kind of abbreviation that doesn't appear, sentence (5), repeated below, from a source like (11),

(11) The boy cut the lemons, and the boy squeezed the lemons.
(5) The boy cut and squeezed the lemons.

and it predicts the non-appearance of two kinds that do in fact appear, (6) and (7).

All but one of the occurring abbreviation types can be described by a syntactic process much simpler than the complex Conjunction Reduction schema, a process which deletes the second of two identical elements across the conjunction and. For example, sentences like (3), (4), (6), and (7) could be derived by such a process from the following source sentences, simply by deletion of the parenthesized elements:

(12) The boy bought some lemons, and (the boy) made lemonade.
(8) The boy bought some lemons, and (the boy bought) a pitcher.
(9) The boy bought some lemons, and the girl washed (the lemons).
(10) The boy threw the ball, and (the ball) bounced over the fence.

The four types of abbreviations above all can be described as identity deletion of a noun phrase of a sequence of words beginning with a noun phrase.[5] No cases of conjoined structures have been found whose derivation from full conjoined sentences would involve identity deletion of a verb or a sequence of words beginning with a verb--thus there are no sentences in the samples like (13) or (14).

(13) The boy bought some lemons and the girl some sugar.[6]
(14) The boy went to the store and the girl.

The following deletion rule would allow the derivation of all the conjoined phrases mentioned above that are found in the samples, with the exception of conjoined subjects, but not of the conjoined structures not found.

(15) SD: $[_S X - \underbrace{NP - Y}_{} - Z\ _S]$ and $[_S T - \underbrace{NP - Y}_{} - W\ _S]$

SI: 1 - 2 - 3 - 4 - 5 - 6 - 7

SC: 1 - 2 - 3 - 4 - 5 - Ø - 7

condition: $2 \equiv 6$

The claim that the subjects' grammar contains a rule such as (15) predicts that certain other types of non-English conjoined constructions should be possible. For instance, it should be possible for the subjects to delete the object of the second sentence under identity with the subject of the first, as in (16), or to perform two deletions, as in (17).

(16) The ball rolled under the house and dog picked up.
(17) The boy cut the lemons and squeezed.

Note that sentence (17) is what the deletion analysis predicts from the source sentence (11) above instead of the non-occurring English sentence (5). Both sentence types (16) and (17) occur in the samples, though less frequently than the kinds mentioned above.

The one type of conjoined phrase that appears in the samples but cannot be derived by the deletion rule is conjoined subjects, as in (1).

(1) The boy and the girl went to the store.

The occurrence of conjoined subjects might be taken as refuting the deletion analysis; however, there are two facts about the conjoined-subject sentences in the samples that militate against treating them as syntactically parallel to other sentences containing conjoined phrases.

First, the children produce conjoined subjects at least two years earlier than any other type of conjunction. Recall that conjoined sentences and conjoined phrases of other kinds appear at age twelve or thirteen, while conjoined subjects appear at age ten. Second, the contexts in which conjoined-subject sentences are used are those where phrasal rather than sentence conjunction would be expected in adult English, and the verbs that occur in conjoined-subject sentences are among those that allow phrasal conjunction in adult English.[7] For instance, sentence (1) above refers to one act of "going", not to two trips. Another very frequent sentence in the samples is (18), which can be assumed, from the stimulus pictures, to refer to an act performed by the boy and the girl together, and not to acts performed by each separately.

(18) The boy and the girl made some lemonade.

So far I have found no cases of conjoined subjects that would be interpreted as sentence conjunction in adult English. The conjoined objects in the samples sometimes have a phrasal conjunction sense, sometimes a sentence-conjunction sense. All other conjunction types seem to require the sentence-conjunction interpretation, with two different actions involved. Thus it seems reasonable to analyze sentences with conjoined subjects differently from sentences with other conjoined phrases, possibly assigning them a phrasal conjunction source. However, I know of no other evidence in the samples that could be taken to support such an analysis.

The deletion rule proposed here for conjoined phrases derives these phrases in a very different way from the Conjunction Reduction schema of adult English; however, there is a very common syntactic process of adult English which to some extent parallels the deletion process in the language of the deaf subjects--Pronominalization. Adult English allows Pronominalization in each context where the samples show deletion of a noun phrase. Thus the parenthesized pronouns in the following sentences make them acceptable for adult English; these sentences appear in the samples both with and without pronouns, showing that Pronominalization as well as identity deletion of noun phrases is possible in the subjects' writing.

(19) The boy bought some lemons, and (he) made lemonade.
(20) The boy bought some lemons, and (he) bought a pitcher.
(21) The boy bought some lemons, and the girl washed (them).
(22) The boy threw the ball, and (it) bounced over the fence.
(23) The ball rolled under the house, and the dog picked (it) up.
(24) The boy cut the lemons, and (he) squeezed (them).

The claim that I would like to make about the conjunction abbreviation process of the subjects, then, is that it is an identity deletion rule whose applicability parallels that of English Pronominalization.[8] Since the subjects allow Pronominalization and deletion in the same environments, it seems reasonable to treat them as two variants of one process. The implications of this analysis of conjunction abbreviation will be discussed after consideration of another type of creative error that appears in the samples.

4. Relativization Errors

Relative clauses appear in the writing samples far less frequently than the syntactically less complex conjoined constructions. The majority of the subjects use at least a few

simple relatives in their five writing samples, but some never use any. On the other hand, questions, whose syntactic derivation is quite similar to that of relatives, are understood very early by the subjects and used very frequently. Relatives formed by use of a subject wh-word, such as the one in (25), first appear at age twelve, while those formed by fronting an object wh-word, such as the one in (26), appear one or two years later and are far less frequent than the former type.[9]

(25) She looked at the boy who dropped the bat.
(26) The farmer pulled the rope which Ken held.

There are several non-English relative clause constructions in the samples, the easiest to interpret being cases of object-fronted relatives which contain an extra noun phrase or pronoun. Examples are (27)-(29).

(27) John and James pulled the rope which Ken hold it.
(28) The dog picked up the ball which the boy threw it.
(29) The little boy got off the car and ran to the dog which he later kneeled hugging the dog.

Sentences somewhat like these occur in some dialects of English and have been discussed by Ross (1967). Whereas in normal English relativization a noun phrase is moved to the front of the relative clause, in the dialects Ross considered and in the writing of the subjects the noun phrase is copied at the front of the clause, the original noun phrase remaining behind and usually being pronominalized. In Ross's terminology, the derivations of (27)-(29) would involve a "copying" rule rather than the English "chopping" rule. Another interpretation of the difference between (27)-(29) and adult English sentences containing object-fronted relatives will be proposed below.

The interesting thing about object-fronted relatives in the writing samples is that nearly all of them contain the noun phrase or pronoun in object position; very few are well-formed in terms of adult English. Moreover, "copying" never occurred in object-fronted questions, as might be expected from the derivational similarity between questions and relative clauses. No questions like (40) were found.

(40) What did the boy find it?

5. Implications

As was mentioned earlier, proponents of the innateness hypothesis generally assume that errors such as those described above reflect whatever is innate about the structure of language or the child's capacity for learning language. I will assume that some form of the innateness hypothesis is correct and attempt to assign a source to the types of errors discussed. In particular,

I will be interested in which of two versions of the innateness hypothesis of language acquisition these errors are consistent with. On one version of the hypothesis, children are viewed as bringing certain innate strategies to bear upon their linguistic input with the result that they "discover" the rules that characterize the constructions in the language. On the other version of the hypothesis, children are viewed as possessing a universal set of rules and bringing their linguistic input to bear upon these rules, with the result that they "discover" which of the universal rules are relevant in their language, the precise shapes of these rules, how they must be restricted, and how they must be ordered.

Thus the two versions of the hypothesis differ in what they claim is innate; but they also make different predictions about the kinds of output that will be found during acquisition. The former predicts, among other things, that creative errors will be made that result from over-generalization of the adult English rules; the latter, on the other hand, predicts that creative errors will be made as a result of failure to correctly restrict one of the universal set of innate rules. The second description rather than the first seems to fit the errors discussed above, although this conclusion depends crucially upon two theoretical assumptions about the relationship between two types of syntactic processes, pronominalization and deletion. Since little evidence has as yet been advanced in support of this hypothesis, the conclusion I reach will necessarily be quite tentative.

I have suggested that the conjunction abbreviation rule is an identity deletion rule and that Identity Deletion and Pronominalication are variants of one syntactic process in the language of the subjects. A number of claims have been made recently to the effect that Pronominalization and identity deletion rules in English and other languages are related, Pronominalization involving deletion of some material from a noun phrase under identity, identity deletions involving deletion of all the material. It has further been claimed that Pronominalization must in at least some cases apply as a condition for later application of deletion.[10] The fact that Pronominalization and some identity-deletion rules share the same constraints aruges in favor of the view that the two rule types are actually variants of one kind of syntactic process.[11]

If Pronominalization can be shown to be a restricted form of a universal identity-deletion rule, then the conjunction abbreviation errors in the samples will be analyzable as failure on the part of the subjects to correctly restrict this universal deletion rule to Pronominalization. However, if Pronominalization and identity-deletion are simply viewed as two similar types of rules, not crucially related by syntactic theory, then the conjunction abbreviation errors will have to be analyzed as overgeneralization of an identity-deletion rule or as the use of a rule not present in the grammar of adult English. The implications of the conjunction abbreviation errors thus depend on the eventual

settlement of the question of the relationship between Pronominalization and deletion rules in syntactic theory.

The implications of the copying errors in relativization are clearer but depend upon the way in which rules like wh-movement are formalized in syntactic theory. There are two alternative ways of formalizing such rules--first, as one-step movement processes, or, second, as two-step processes which involve copying an element and then deleting the original. Ross (1967) did not attempt to determine which of these formalizations of variable-movement rules is correct, but only the second yields an interpretation of the "copying" dialect of adult English and the "copying" errors in the writing samples which relates these in an interesting way to relativization in adult English.[12]

The most reasonable way of analyzing the "copying" sentences, such as (27), repeated here, is to claim that they are derived by making a wh-copy at the left boundary of the relative clause of the noun phrase in the relative clause that is identical to the head noun phrase, then pronominalizing the original occurrence of this noun phrase.

(27) John and James pulled the rope which Ken hold it.

The derivation of (27) according to this analysis would take a structure like (41) and convert it first to (42) and then to (27).

(41) John and James pulled $[_{NP}$ the rope $[_{S}$ Ken hold the rope.$_{S}]_{NP}]$

(42) John and James pulled $[_{NP}$ the rope $[_{S}$ which Ken hold the rope.$_{S}]_{NP}]$

In the derivation of some of these "copying" sentences, Pronominalization doesn't occur, for example (29) above, and the sentence retains a full noun phrase within the relative clause rather than a pronoun.

If this analysis of the "copying" sentences is correct, and if we assume the second of the two formalizations of movement rules outlined above, i.e., that they proceed by copying and then deletion, then the only difference between the "copying" relative clauses and the relative clauses of adult English will be that in the former cases the original occurrence of the noun phrase is pronominalized, while in the latter cases it is also deleted. Thus it will be possible in view the "copying" relatives as produced by a failure on the part of the subjects to properly restrict relativization to deletion of the original noun phrase. I see no way in which the "copying" relatives can be interpreted as overgeneralizations of some English process.

In the conjunction abbreviation errors the subjects delete where Pronominalization is required in adult English, while in the relativization errors they pronominalize where deletion is required. Of course, my analysis of the relativization errors depends, like

my analysis of the conjunction errors, on the relationship between Pronominalization and deletion in syntactic theory. Given the assumption that Pronominalization is a restricted form of deletion, the conjunction errors are produced by failure to restrict the deletion process enough, while the relativization errors are produced by too great a restriction on the deletion process.

In conclusion, I have claimed that the conjunction and relativization errors discussed should be viewed as resulting from failure on the part of the subjects to properly restrict a universal syntactic process, Identity Deletion. This claim, however, has been shown to depend upon two theoretical assumptions that have not yet been thoroughly substantiated--that Pronominalization is a restricted form of a universal process of deletion, and that movement rules like wh-Movement are to be formalized as proceeding by copying and deletion. The existence of these two types of errors, if interpreted as resulting from failure to properly restrict universal rules, provides support for the version of the innateness hypothesis which claims that children possess a set of universal syntactic processes and bring linguistic input to bear upon these processes to restrict and order them.

Footnotes

1. The form of this paper was influenced by discussions with Michael L. Geis.

2. The analysis of the writing samples was supported by Grant No. OEG-0-9-232175-4370(607) from the United States Office of Education, Bureau of Education of the Handicapped.

3. The Conjunction Reduction schema has been described by Schane (1966) and Ross (1967).

4. There is another rule of English, Gapping, which abbreviates full conjoined sentences not meeting condition B--sentences in which the identical elements are verbs preceded and followed by lexical material.

5. The samples contain some sentences which might be described as derived by deletion of a second tense element on identity with a first. Examples are (i) and (ii).

(i) The boy threw the ball, and it bounce over the fence.
(ii) The woman saw the boy who drop the ball.

Such sentences are not very frequent and will not be considered here.

6. Sentence (13) in adult English is derived by Gapping, not by Conjunction Reduction. No constructions appear in the samples which could be claimed to be derived by Gapping.

7. The differences between phrasal and sentence conjunction are outlined in Lakoff and Peters (1969).

8. The subjects' use of Pronominalization does not in fact exactly parallel adult English Pronominalization. Forwards

Pronominalization is the only type that occurs in the samples. Although sentence-initial adverbial subordinate clauses are quite frequent, providing many environments where backwards Pronominalization would be possible in adult English, not a single case was found in the samples.

9. Object-fronted relatives could be claimed to be syntactically more complex than subject-fronted relatives in that the derivation of the former, but not of the latter, involves a change in the linear order of formatives.

10. See Langacker (1969) and Postal (1968). In two lectures at The Ohio State University in the fall of 1971, David Perlmutter argued that Pronominalization is a prerequisite for certain syntactic deletions in Slovenian.

11. Paul Postal (1968) showed that the rule of Equi-NP-Deletion can apply only in environments where Pronominalization can apply. Another deletion rule that obeys Langacker's (1969) constraints on Pronominalization is Verb Phrase Deletion. In Japanese, and possibly in other languages as well, Pronominalization is effected by a rule which deletes, rather than pronominalizing, one of two coreferential noun phrases.

12. Drachman (1970) has claimed that the formation of relative clauses always involves copying, pronominalization, and deletion rather than simple movement.

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Physiology and the Acquisition of Phonology[1]

Gaberell Drachman

1. In this paper I shall extend to the acquisition process my earlier discussion (Drachman 1970a) concerning the relationship between phonological rules and the physiology of speech production. In that paper I showed that the response of the tract to the demands of a finely detailed and language-specific rule-system was to initiate certain global configurations and timing relationships, which I identified with the classical notion the 'Basis of Articulation', so as to guarantee ease of articulation to the real-time rule-guided processes of speech production for the language concerned. In summary I concluded that, for the mature language speaker, the tract has come to terms with the rule system.

What I want to examine here, on the other hand, is how the content of the rules for the earliest stages of phonological acquisition is itself at least partly dictated by the speed and ease with which certain muscle coordinations (in their paradigm and sequence relationships within a language) are mastered by the developing child. To the extent that this proves true, the tract may be said to dominate the rules--for the time period concerned.

I shall outline a simple model for the maturation of articulatory control, and suggest how such a model may capture the facts for at least the earliest stages of acquisition. It is a very primitive model, so far solving only a few of the problems--but it is only meant to be suggestive, or at most programmatic.

2. From the co-articulation studies of Öhman (1966), the cineradiographic studies of Perkell (1969), and the computer-simulation studies in Lindblom and Sundberg (1969), the following simplified three-part model for adult articulatory control emerges.

First, there is a functional division of articulatory activity into two overlapping classes: vowel articulation is accomplished mainly by the large, slow-moving extrinsic tongue muscle system--controlling gross tongue position; on the other hand, consonant articulation requires not only this first system but also the superimposition of the smaller, faster-moving and more complex intrinsic system of tongue muscles--controlling local tongue deformation. The intrinsic tongue muscles in turn fall functionally into (at least) two groups: the one controls the raising of the tongue tip; the other, the bulging or depression of the mid-line of the tongue in the palatal, velar, or pharyngeal region.

Second, there is superimposed on this double system for positioning and deforming the tongue, an over-riding pressure consideration. At least three degrees of oral pressure are required:

for the stops a sharp, maximal increase; for the fricatives, a less extreme increase, with controlled airflow; and for the nasals, a total pressure-relief coordinating with maximum closure of the tract.[2]

Third, as for all skilled behavior, a feed-back control system must be added;[3] I propose the following mixed system, which is at least consistent with the present state of our understanding.

For the place of articulation, feed-back may be achieved mainly by tactile feedback from the contacting members. For manner of articulation, the pressure in the oral chamber may itself be monitored,[4] in conjunction with acoustic feedback. For the vowels, control is probably achieved through acoustic feedback, but also through the muscle-internal sensors known as spindles.[5]

3. The preliminary maturation model which I tentatively propose considers the mastering of an increasingly complex interaction between these three subsystems--extrinsic tongue, intrinsic tongue, and pressure-control--in conjunction with the jaw, lips and velum. The model predicts that motor control of the speech musculature as used for speech is at first gross, then fine, with respect to developmental neurophysiology,[6] and might well mature in the following overlapping stages for the early acquisition period.

At the first stage the tongue-extrinsic system begins to be mastered, and the pressure system is commanded only at its polar values, maximum pressure alternating with minimal pressure. On the other hand, the tongue-intrinsic musculature is not yet brought at all into relation with either the tongue-extrinsic system or the pressure system. Maximum pressure corresponds of course to stoppage; since the extrinsic system is mastered first, this involves only the jaw-lip subsystem and is achieved by ballistic impulse--giving the bilabial voiceless[7] stop [p]. Contrariwise, minimal pressure produces a vowel, whose quality is dictated--like the sequence alternation CV (later, CVC)--by polarity of the total extrinsic system; thus, the most peripheral stop is paralleled by the most opposed configuration[8] of the tongue-extrinsic system--the result is the vowel [a].

At the second stage, the tongue-intrinsic muscle-system is brought into play, but the pressure-control system remains polarized. The most mobile part of the tongue proves to be the tip and blade,[9] and this is indeed what is activated first within the newly developing sub-system:[10] its interaction with maximal pressure gives the stop [t]. The inventory of possible utterances is thus increased to [pa, ta].

At the third stage, the pressure-control parameter is diversified, though without involving finer degrees of control; mastery over the raising and lowering of the velum in coordination with oral stoppage (through either the extrinsic or limited intrinsic system) produces an oral median stop without pressure being built up in the oral chamber. The outcome is the continuously voiced [m] and [n].[11] Now the system is capable of [pa, ta; ma, na].

Finer control of the pressure parameter might be expected to proceed from stops to approximants, with fricatives following. Thus, we expect next the bilabial approximant [w], together with the blade approximant [y].

A still later stage must, it seems, be postulated for the achievement of the even finer command of the pressure system required for fricatives. Like the approximants, the fricatives entail controlled rather than ballistic approach of the moving articulator, but the latter to such a degree of constriction as to generate turbulent rather than laminar air-flow. For this stage should be added [f, s] and the resultant total inventory is [pt, mn, fs].

Before considering how far the ordering of the stages suggested is born out in available acquisition data, three remarks are pertinent.

First, for each set of 'places' there are relative difficulties. One example is the simple difficulty of articulating [f] until the front teeth are all present; but against this is to be balanced the fact that [s] is not at all a simple blade articulation--rather, the tongue must be grooved along its center line.

Second, not all positions in the word (or phrase) will prove to be equally difficult. If this is in any way connected with articulator-timing requirements, one might predict (for example) that nasals will first appear word initially, rather than medially or finally. Despite the fact that the velum is raised as part of the speech-ready configuration, it is also clear that an initial nasal partly inhibits velum raising.[12]

Third, there are global qualities of utterances (at this stage, probably single words) such as the assimilatory dominance of voicing. This is probably to be associated with the absolute dominance of the vowel-gesture (on which consonants are superimposed); and results in a tendency for all pre-vocalic consonants to be lax:[13] while the opposed trend, to assimilate to the following voicelessness of non-speech breathing, is equally seen for final consonants.

4. How far, now, does the above account correspond to known facts concerning acquisition?

First, the polar functions of muscle and pressure systems correlate with the systemic oppositions of Jakobson's (1968) account, for which they in fact supply a physiological basis. Thus, for example, the notion of a segment with maximal oral pressure (a stop) opposed to one with minimal pressure (say, a low back vowel) has physiological as well as systemic priority.[14]

Second, the ordering of (my) second and third stages shows some alternation in the data. Jakobson (1968) holds that the first consonantal opposition is that of the nasal and oral stop, which is followed by the opposition of labials and dentals. I have, on the other hand, suggested that the intrinsic tongue system is already active before the pressure control is diversified. But note that from the point of view of physiological complexity, the added complications are somewhat equal--so that some children master

the velum co-ordination before bringing the tongue-intrinsic system into play, However, in Velten (1943) and Leopold (1947) we have the chronological sequence [p - t, then m - n] here predicted.[15]

The comparatively late appearance of fricatives is predicted by both Jakobson and the present account; again, one systemic and physiological grounds respectively. Joan Velten, however, had [pts] within 13 months, [f] at 14 months, but no nasal until 17 months: still more irregularly, Hildegard Leopold first shows a spirant [š] not only before the appearance of [t] in the same position (finally), but also before the appearance of [n] in any position.

Both the Velten and the Leopold data suggest that the CV pattern is first broken, and CVC established as a unit of production, with final spirants[16]--and it is in final position that the acquisition-ordering irregularity occurs. Synchronic and diachronic studies concerning loss of final consonantisms support the conclusion that it is the syllable (and thus word) position constraint that is important here, rather than the abstract notion 'inventory'.

The appearance of the palatal spirant [š] in final position (Leopold) presents an interesting puzzle. First, [š] at 17 months is found only as a substitute for final [s]--underlying [š] being still deleted at this stage. Note that the common substitute for initial [s] at the same stage is [j], also palatal; thus, in the maturation model, for a production unit type CVC, the pressure-control parameter comes under fine control earlier for the final than for the initial segment.[17] If we add to this the prediction that tongue grooving will present special problems, and that some children will thus prefer a non-grooved spirant,[18] we account for the fact that the [s]-substitute in initial position may be the approximant [h]--corresponding to [s] itself; or, it may be a fricative [j]--fairly closely corresponding to the non-grooved alternant substitute [š].

5. I have supposed that during acquisition the child is experimenting in his search for a set of physiological mechanisms by which he may best represent and reproduce the structures inferrable from the speech he hears around him. But the model I outlined initially quickly proves to be somewhat rigid and simplistic, and even the samples of data I have cited show clearly that there will be a range of available strategies for each stage. But it is also reasonable to claim that the range of strategies that proves to be available at different stages is at least partly dictated by the maturing ability to command and integrate the appropriate physiological sub-systems.

Footnotes

1. A fuller version of the present paper was originally read at the LSA meeting, July 1970. I wish to acknowledge the helpful commentary of Harry Whitaker, as a result of which a number of important points in this paper were clarified or amplified during 1970. However, for this publication (1973), I present only the first half of the paper; this gives the model itself, but only a hint (section 4) as to how well it explicates known acquisition data.

2. The laterals seem to require the same degree of pressure-relief as the nasals, vowels and semi-vowels. In my view, the notion "force of articulation" is at least partly to be accounted for in terms of oral pressure, the "force" being necessary to contain a given pressure, and giving rise in turn to (e.g.) longer closure for voiceless than for voiced stops.

3. The 'bias', or feed-forward system involves an additional set of priming features clearly related to the 'Basis of Articulation'.

4. Malecot's (1966) experiments (unfortunately not yet replicated for young children) suggest that subjects are sensitive to oral pressure differences as small as those obtaining during normal speech. It is possible that place of stop-articulation is also 'confirmed' via the spindles, since it is known (Houde, 1968) that tongue-deformation during the closure for stops correlates with intra-oral pressure.

5. Cf. the review of non-acoustic feedback mechanisms in Hardcastle (1970). Whitaker points out (personal communication) that of course of the three types of feedback, acoustic feedback applies to the output of the entire tract, whereas proprioceptive and tactile feedback apply only to parts of it. Even more suggestive is his remark that this distinction may correspond to that between a cortical (acoustic) and a purely brain-stem (the rest) type of feedback loop.

6. One would expect corroborative evidence from the neurological sciences for such a notion, as regards not only the motor commands, but also those for feed-forward (anticipatory) and feed-back. For doubts on the role of proprioception see also MacNeilage (1970) and for outright scepticism Konorski (1967), and Wickelgren (1969).

7. The oral pressure condition naturally results in voicelessness for obstruents (cf. Halle and Stevens 1967). For the state of the velum, up is unmarked--since this is part of speech-ready 'priming' (i.e., part of the Basis of Articulation) and probably a universal element.

8. Reciprocal innervation is perhaps the neurological correlate to "opposed configuration".

9. See Cooper (1953), Dixon (1961).

10. Feedback, both tactual and proprioceptive, is richer for the front of the tongue than for the rest of the oral region (or, for that matter, the whole of the rest of the body (Cf. Dixon 1961)).

11. The other continuously voiced oral median stop is the lateral [l], the added complications concerning which I discuss elsewhere ("A note on the Acquisition of [l]," mimeo, 1970b).

12. This may be seen in the nasal sonde recordings in Kozhevnikov and Chistovich (1965).

13. As the data in Leopold (1947) suggest, this also results in a tendency for unstressed vowels to assimilate to preceding stressed ones.

14. Note that the present account does not necessarily predict [p] as the 'first' consonant, although of course it does not preclude it either.

15. Tantalizing is the fact that from 13 months to 19 months, Hildegard Leopold attempted no words with initial [t]--in fact, until both nasals were in her inventory!

16. It is surely relevant that the first clusters are not only also found finally, but also involve [s], as in Velten's [uts] for 'cats' and [futs] for 'fix' (22 months).

17. This does not of course account for the absence of final stop [t] at a stage where final spirants are present.

18. The account here emphasizes, while not solving, the general problem of why a child may be unable to produce a given sound, and yet able to produce it as a substitute for an other sound. I shall take up elsewhere the question whether the 'substitute' is in fact homologous for articulation with the adult model.

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Assumptions about Acquisition[1]

Gaberell Drachman

1. In this paper I propose to deal mainly with the problem of babbling, but treating it as an integral part of the process of phonological acquisition rather than as an autonomous process.

The essence of the mystery associated with babbling is, as Jakobson (1968) puts it, that whereas the child at the height of his babbling period is capable of producing all conceivable sounds, he then loses nearly all of this ability to produce sounds, in passing over to the first genuine stage of language (the first acquisition of words). Crucially, however, the child does not lose only those articulations lacking in the environment language, but (and this despite putative evidence that apparently neither the perceptual nor the production mechanisms are in themselves faulty at this stage) also many sounds common to the child's babbling and the adult language of the environment.

Now I do not wish to argue here, against Jakobson, the question of whether either the child's perception or production <u>are</u> in fact perfect for all segments in all positions and under all conditions of stress and intonation;[2] nor whether, considering the massive homonymy of output for the earliest stage, the 'true onset of language' is indeed definable (as Jakobson implies) in terms of the 'first acquisition of words';[3] nor, thirdly, whether the child's articulations are in fact even homologous with those of an adult for given similar segments[4]--though I think it fair to say that all these assumptions are open to serious question.

On the other hand, neither will it be necessary, for present purposes at least, to agree or disagree with Menyuk's contention that babbling develops in the same order of feature utilization as does (what she calls) the morpheme construction period;[5] or that Gruber's (1966) claim that babbling is always intentional--though not intendedly intelligible.

I want instead to explore some of the positive analogies between the progress of phonation in children, and the development of certain other highly organized activities that very young children (and other animals) are capable of. I shall argue that these analogies are material: and this is to claim that we do not have to do simply with a series of suggestive metaphors, but rather with a single unifying and explanatory principle--that of biological maturation, which underlies and accounts for not merely the onset of speech, as Lenneberg (1967) has held, but also much of its subsequent development, at least in the acquisition of phonology.[6]

2. Many of the neuromuscular functions of the newborn infant are organized into definite discernible patterns, three of the most striking of which are as follows (McGraw, 1966).

1. A newborn infant may grip a rod sufficiently to suspend his own body-weight in mid-air for several seconds or even minutes.

2. He will, when immersed in water in a prone position, manifest definite rhythmical swimming motions of his arms, legs, and trunk.

3. If supported under the arms in an upright position so that his feet can touch the floor, he will frequently engage in rhythmical stepping movements--making as many as ten to fifteen consecutive 'steps'.

Now I want to suggest that there is an important parallel between these patterns and that of infant phonation. However, the true nature of the maturation process is revealed only when we study the progressive change in each function from its inception until it attains a state of relative stability.

Take suspension-gripping. According to McGraw (see diagram A, pp. below), the intensity of this response (suspension-grasp ability) increases during the first thirty days. Then there is a decline, during which (at least) single-handed suspension is entirely suppressed. There follows a period of fluctuating ability from about 100-400 days, and finally a renewed steady increase--the ability of a 30-day old infant not being equalled again until after about 4 years.

We thus see four phases: the neonate seems to show increasing ability, then nearly total loss of ability, then disorganization and confusion, and finally, smoothly integrated action.[7]

With variations in the duration of each phase and in the overlap between phases, the other neonate behavior patterns mentioned show parallel developmental schedules: reflex, inhibition, transition, smooth coordination. Now the analogy to phonetic behavior is irresistible--where the corresponding stages would be babbling, relative muteness, substitution and mature ability. While the neurophysiological explanation of the pattern I have illustrated is not clear in detail, it is reasonable to assume a transfer of control systems, in turn correlating with the child's dawning consciousness that meaning is to be associated with sound. If McGraw is right in her supposition, this shift of control [perhaps from lower to higher centers[8]] involves massive inhibition of the earlier control system--and this it is that results in a temporary cessation of function.

3. My second argument is that, despite this inhibition phase, there are in fact important continuities between the earliest vocalizations and speech proper. I shall cite four examples: infant cries, breathing rhythm, syllable-structure, and Register phenomena.[9]

First, consider infant cries and screams. The commonest vowels heard in infant crying are [a] and [æ], vowels the frontal quality of which can hardly be attributed--as some would seem to wish it to be--to the fact that the child is lying on its back! Rather, it suggests that new-born infants cry with a rigid tract, as Lieberman (1968) claims--and if this is so, then there is a curious anticipation

here of the so-called speech-neutral tract in the adult--which is (at least for English--see Perkell (1969)) such as would produce some kind of mid-to-low front vowel.[10]

Next, let me refer to early control of the rhythm of speech-breathing. It is well known of course that speech-breathing is quite different from rest-breathing--inspiration being markedly shorter than expiration. Now the fact that babbling frequently consists of sequences of up to five syllables at a time shows that for the period of babbling this particular part of the speech program is already operative. [I note in passing that the swimming behavior of the infant, referred to above, is accompanied by yet another reflex ability--later lost; instead of coughing or swallowing water, the infant simply holds his breath.]

A third element that carries over from babbling, at least into the early stage of imitation, is the syllable shape CV itself,[11] together with the tendency to perseveration, i.e. reduplication of the shape CV[12]--a universal characteristic of early child language.

Perhaps the most striking of the features carried over from the earliest stages into even mature language use, are those known as Registers--those features of production conveying information or emotion beyond that conveyed by the words alone (Cf. Weeks (1970)). I refer here to two of these, whisper and whining.

(1) Whisper. Children very early master the register use of whisper. But note too that whisper may first appear in babbling. Preyer (1914) refers to whispered babble monologues, as does Gutzmann (1894). In turn, early imitative forms in whispered speech are given in Leopold (1947) at 12 months. We also see in the Leopold data the gradual transfer to adult use of whisper: at 17 months, child-type use is becoming rare, while by 20 months[13] the adult use is fully established.

(2) Whining. Lastly, I mention the register we might call whining, used for complaining and frustration crying by most children. Note that whining is characterized by an open velum, whence of course the nasal quality: but this is precisely the configuration (viz., nasalization) used by the newborn infant wailing in discomfort--cf. Lewis (1936).

I now claim that, since a number of important elements of speech carry over from babbling into mature language use, the inhibition I talked of may not be referred to as the inhibition of an ability--but only of performance, or output. It is thus only temporary suppression of output that characterizes the change-over of control programs for a given function, as my labelling of the graph (A, page 79) indicates.

4. My third argument is this: if my global analogy between phonological development and the schedules of neuro-muscular development is correct, then of course the stage of phonetic substitutions ought to show the characteristics of the third stage of maturation, viz., disorganization and confusion. A typical complex movement pattern such as walking shows in its development:

1. plateaus and spurts.
2. regressions and reversals.

Let me take a small problem in phonetic (production) acquisition to illustrate the apparent parallel in language.

In a longitudinal study of differential vowel length in American English at the University of Wisconsin, Naeser (1970) has shown that, for some vowels at least, differential length seems to fluctuate and even to reverse, until at length it stabilizes at its English-specific norms.

However, I want to suggest that this conclusion presents only an apparent parallel--for there is of course far more complexity to both walking and language than appears so far. In particular, as McGraw is careful to point out, even where some part of the pattern seems to lag behind, there is overall development going on all the time. Thus, reflex stepping is inhibited for the time during which postural (anti-gravity) control is improving; only then does the further voluntary control of progressive movement become possible.

For the parallel with language, however, a rather wider range of vowels than that handled in Naeser's paper is required: I shall use the data in Velten (1943).

The data under (B) on page is a sample from Velten's six stages[14] in the development of differential vowel length in the English of his daughter Joan.

At 11-20 months, vowel length depends simply on (underlying,[15] not produced) syllable structure; thus, final l counting as syllable, doll has a long vowel as well as pie, both counting as open syllables.

At 23 months, vowels are first differentiated by length in closed syllables. But notice that it is the low vowel [a] that is lengthened--low vowels being universally longer than non-low vowels, context for context.

At 24 months, a series of interlocking reorganizations occurs. At stage (a), two further contextual lengthening factors come into play; the universal lengthenings by a following voiced stop or voiced spirant. As at the earliest stage, the 'environment' for this change is the representation, not the produced segment (as Naeser's study also showed): thus wet is [wut] but red is [wu·t]--i.e., lengthening occurs on the basis of the underlying (heard) representation.

At stage (b), underlying voiced stops are produced at length as voiced--but only word-finally, in the environment newly affected by vowel-lengthening.

At stage (c), following this, the underlying vowels [ʌ] and [ɛ], (non-high non-round, produced as [a, u]) lose their newly-acquired length. The fact that these are Lax vowels suggests that what is being 'acquired' is mastery of the Tense-Lax distinction, a notion confirmed by the final phase given here.

Fourth and lastly, at stage (d), the underlying vowels [i, e, o, ə, u] are produced as long [u.] under stress. But these are the (non-low) Tense vowels, which universally are intrinsically longer than their Lax counterparts.

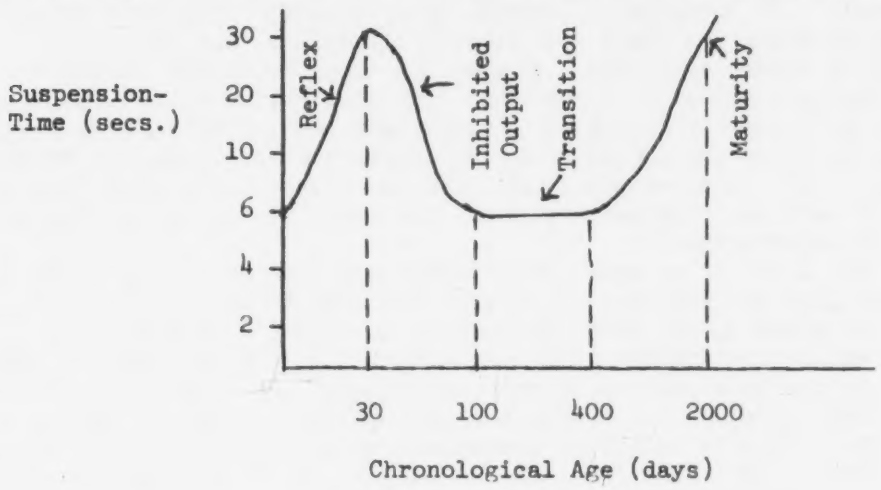
Summarizing now from the two right-hand columns of the data (b, page): at stage 1, control is by syllable structure alone; while at stage 2 appears the intrinsic length of the vowel [a], added in closed syllables. Stages 3-6 show the stages in the developing importance of the Tense-Lax distinction--thus with Stage 3 the influence of following voiced stops and spirants; with Stage 4, final stops and spirants are at length distinguished for voicing; while in the final stages (5-6), the Tense-Lax distinction finally spills back into the major part of the vowel system, with appropriate length adjustments.[16]

The moral of my story is a double one. Although the vowel in a word such as 'mud' must have been short at stage 2, it is then long at stage 3, but then short again at stage 5--thus showing apparently gross fluctuation over a period of only two months; but what is really happening is that an ordered series of interlocking adjustments across the system has taken place.[17] But it is also important to note that the representation that must underlie these processes is a stable one, and can only be one essentially identical with that of the adult model.

5. To sum up, the development of a child's phonetic output in language acquisition correlates in gross outline with the phases of neuromuscular development established for other patterns of complex movement, these phases being: reflex pattern; temporary inhibition of output; transitional stage of interlocking re-organization of sub-systems; and mature, smoothly achieved functioning.

The hypothesis of this paper is that these correlations are not accidental; not merely in onset (the babbling stage) but for a great deal of its later development, language shows the hallmarks of a complex innate maturation process. The laws controlling this process and especially its interaction with learning in the usual sense--remain to be clarified.

(A) Grip-suspension in the new-born child [Modified from McGraw 1966]



(B) Acquisition of contextual vowel-length (Data from Velten 1943)

					Stage	Dominant factor
11-20 months		ba da	'bottle' 'down'	ba· da·	'pie' 'doll'	1	Syllable structure
23 months		dap but	'cup' 'bread'	da·p da·t	'top' 'dark'	2	Cá·C
24 months	(1)	nat wut dus	'nut' 'wet' 'goose'	ma·t wu·t nu·s	'mud' 'red' 'nose'	3	V → Long before {voiced stop / voiced spirant}
	(2)	dut wut dus	'coat' 'wet' 'goose'	ma·d wu·d nu·z	'mud' 'red' 'nose'	4	Stops & Spirants → Voiced ≠ Voiceless in final position
	(3)	wut mad wud	'wet' 'mud' 'red'			5	Re-shortening of least marked Lax vowels
	(4)			du·t du·s	'coat' 'goose'	6	Non-Low Tense vowels → Long

Footnotes

1. Paper read at the LSA Meeting, December 1970. For the present publication (1973), only minor stylistic changes have been made. (But cf. footnotes 6 and 14).

2. Consider, for example (a) arguments from child confusions of comprehension, e.g., Abbs, Minfie (1969); and (b) arguments from acoustic cues in final stops vs. spirants.

3. A question of ascertaining an intention regarding meaning-sound correspondence, for a stage when all forms have, say, [ba] as their output.

4. Cf. Preyer (1914), p. 110--in crying [rrra] at 11 months, Axel Preyer showed "a vibration on both sides of the edges of the tongue, which is bent to a half cylinder with the ridge upward".

5. From which it might perhaps be assumed that at least some late phase of babbling will show language-specific feature use: but cf. the negative findings on adult ability to discriminate between the babbling of young children from different linguistic communities, in Atkinson, et. al (1970).

6. Cf. the parallel intuition in Bever (1961), of which the author apprised me in January 1971.

7. For the swimming reflex, certainly, evidence suggests that such patterns are common at least to mammals--reflex swimming has been elicited from very young rats, kittens, rabbits and rhesus monkeys (McGraw, 1939).

8. Her earlier (1945 edition) explanation of such phenomena, based on a "geological" model of the brain, assumed the shift was from brain stem to cerebral cortex; later (1966 edition) with a "central systems" brain model, the shift is assumed to be from lower brain stem to Reticular Formation.

9. For a survey of the literature on intonation, see Kaplan (1970)--though there is some question of the relevance of habituation techniques of the kind there described to the problems of normal language acquisition.

10. A direct consequence of which is of course the omission of the Distinctive Feature "Front" in Chomsky-Halle (1968).

11. So strong a pattern as to lead to vowel prosthesis as an alternative to loss of a final consonant: thus #CVCV# alternates with #CVØ#, for an underlying #CVC# shape.

12. Cf. thumb-sucking, another example of repetitive response labelled "primary circular reaction" in Piaget (1954).

13. It can hardly be coincidental that this is the point at which Hildegard Leopold also completed the suppression of the tendency to voice by assimilation all pre-vocalic (i.e. initial and medial) consonants.

14. David Ingram has reminded me (personal communication, Feb. 1971) that in fact more than six stages are discernable in the data, especially the earliest stages. Since this fact only further confirms the present thesis, I have left the text unmodified.

15. That 'lengthening' is rule-guided, rather than merely a question of imitation, is clear from Naeser's study: 'long' vowels were always grossly overlength.

16. The fact that contextual vowel length is largely established while only two vowels are yet distinguished is a strong argument against the notion that distinctiveness dominates phonological acquisition. Not only do the facts contradict the notion "bi-unique phoneme", but non-distinctive features are obviously as important as distinctive ones at this period.

17. Of course the details of such a reorganization are expected to reflect individual strategies--which, in turn, is what makes statistical averaging perhaps less valuable than detailed longitudinal studies on single children.

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Some Strategies in the Acquisition of Phonology [1]

Gaberell Drachman

1. Introduction

A model for the acquisition of phonology must account not only for the gross uniformities of the process from child to child and language to language, but also for the individual detailed variations we see in the case histories. The two elements of the model that perhaps throw most light on this problem of variation are maturation and strategies.

The importance of neuro-physiological maturation for the very earliest stages of the vocal behavior of the child is becoming obvious enough (e.g. Bever, 1961; Drachman, 1970b), though its details remain obscure. It is equally obvious, however, that as maturation begins to interact with the learning process, the notion of strategical choice must be brought into the account. In the present paper, I shall consider how the nature of representations, rules, and the functions of rules correlate with the use the child makes of (that is, the strategies by which the child employs) his articulatory abilities as they mature.

As a preliminary to my discussion of representations, let me briefly survey the question of infant perception.

2. The acoustic representation

The work of Stevens (1968), confirmed in part by that of Lindblom and Sundberg (1969), is very suggestive for a model of acquisition. This work shows, albeit by computer simulation, that vowel and consonant articulation positions do not constitute continua (as opposed to the view implicit, e.g., in Ladefoged 1967). Rather, there are optimal configurations at which comparatively large articulatory perturbations result in minimal changes in the acoustic output. The main optima apparently occur at the configurations corresponding to the primary cardinal vowels and the labial, dental, post-alveolar and velar positions of articulation; and cross-classification based on the characteristics of such articulatory-acoustical plateaus would seem to define the distinctive features.

It follows now that, for a viable communication system, this acoustic stability over a range of articulations should be matched by a perceptual stability (or invariance) over a range of sensations: perception should accentuate the plateaus, with consequent categorization of stimuli. But though the work of Liberman (1971) had already shown that such speculations from considerations of

the adult tract indeed apply to adult perception, this categorization could possibly--at least for the adult--be characterized as learned-in. Is there any real evidence, then, that the very young child can and does make categorical judgments concerning the language sounds he hears?

From the experiments of Bronshtein and Petrova (1952) in Russia it was already clear--using habituation-dishabituation techniques[2]--that a child less than one day old can distinguish musical tones, and the work of Kaplan (1970) at Stanford carried this over to sentence-final intonation contrasts in 4-8 month old children. More important, perhaps, is the evidence in Moffitt (1969) showing--by techniques similar to those in Bronshtein and Petrova--that a 5-6 month old child can discriminate between (synthesized) BAH vs. GAH. That in Eimas et al. (1971) in turn showed that the child makes categorical discriminations among stimuli synthesized to allow a single cue (voice onset time) along a continuum, for voicing in the consonants /p-b/--as early as one month.

These test results are of considerable importance, for they suggest that categorization in the speech mode of perception, at least for voice and place of articulation, is operative at a very early age; that is, that children in their first month have already paid sufficient attention to the language spoken around them to have discovered what Liberman called 'phoneme boundaries' for voiced vs. voiceless stops, at least in a word-initial position.[3]

Conversely, is there any important evidence that perception is somehow imperfect at an early age? First, leaving aside citations such as Jakobson's regarding confusion between nasalized and non-nasalized vowels in French (Ronjat, 1913), consider the experimental data. The work of Tikofsky and McInish (1968) suggests that 7-year olds on a forced discrimination test had highest error scores for the place of articulation feature /f-θ, v-ð/. Other research (Abbs and Minifie 1969) confirmed this for 3-5 year old children and showed also that, of the fricatives, these same pairs show minimal spectral difference.

Second, there is a sense in which, if Jakobson's (1968) implied comparison of auditory perception with color perception is valid, there ought to be a deficiency in infant auditory perception. It ought to be the case, for example, that earliest hearing distinguishes only between consonant and vowel; then among the vowels, and similarly among the consonants--just as the production system does. However, again consider the evidence, which I intentionally select at points that straddle Stevens' plateaus, viz., the labio-dentals vs. the interdentals. If this critical distinction is achieved, there is proof positive that perception is not a crucial problem, at least by the ages cited.

A. /f/ The Velten child has h^w initial, f final (15m):[4]
f everywhere by 22m.
/θ/ The Velten child has s initial, f final (22m):
s is final at 30m (Velten, 1943).

B. /f/ The Leopold child has w initial (23m), f final (?).
/θ/ The Leopold child has d/w (23, 25m), s/f (22m) (Leopold, 1947).

C. /f/ The Smith child has w initially, p finally (24m).
/θ/ The Smith child has g initially ('thank you'), t finally (24m). N.B. at 26m, 'thumb' appears as [wʌm]. "Hitherto he had always refused to say 'thumb', insisting it was a finger [wiŋgə]." (Smith, 1970).

Noting that we make no argument from merger, only from distinction, the following points are relevant for these children.

1. The Velten child has no forms in θ until 22m, but then distinguishes θ - f.

2. The Leopold child has no forms in f for 22m, or for θ for 23m.

3. The Smith child has f-forms, but no θ-forms until 26m.

Note that the critical data, that concerning discrimination in minimal pairs, is quite absent in studies of acquisition, though earlier accounts (such as that of Preyer)[5] give partial lists of objects (body parts, household articles) which the child can identify by pointing, or commands the child can carry out.

However, it is reasonable to hold that children of the ages cited here indeed know words like (a) foot, finger, fix, feed, fall: knife, off, roof, laugh; (b) thumb, thing, three, throw, thank: tooth, bath, cloth, mouth, with.

If this is so, then the absence of such forms from the corpora suggests not accident but design--viz., avoidance, a strategy in this case connected with insecure representation.

However, this problem of insecure representations aside, and barring simple mistakes, there seems every reason to believe that the underlying acoustically based representation (hereafter, Representation I) corresponds substantially to the adult surface form by the time meaning has begun to play its fundamental role for the child, and that this representation is one in terms of segments composed of Distinctive Features.[6]

There is of course yet a further representation, in part derived from Representation I (the primary acoustic representation), in part reframed in accordance with a higher level analysis taking morphological and syntactical facts into consideration. This representation I do not discuss here for, to a considerable degree, it takes us out of the realm not only of acoustic and output representations but also of physiologically based processes (at least so far as the synchronic description is concerned), and involves us in what we must call the abstract representation and the learned rules of the language.[7]

However, the setting up of higher level abstractions is not the only way in which the primary representation may require modification. Consider that a possible strategy for setting up Representation I from the first raw acoustic data might be the following:

"Keep it as simple as you can."

The temporary use within Representation I for the Korean stops, of a feature "voice onset time" (VOT) might be an example of such a simple-minded strategy. But such a representation would require modification (perhaps to Tense vs. Lax [compare Kim, 1965])[8] even before production is attempted, in fact as soon as a number of cases occurred of understood utterances involving stop-final morphemes with vowel-initial following morphemes; here the inter-vocalic stop assigned "VOT degree 2" voices through, while that assigned "VOT degree 1" does not--against expectation. But notice that a simple "Modification of Representation I" strategy is likely to resemble the instruction.

"Do what you must--but only <u>where</u> you must,"

with the result that only stops in the critical position would require re-analysis. This suggests the possibility of multiple representations, or at least ambiguous representations, in the non-critical morpheme positions.[9] It is not clear that such ambiguities would ever be resolved.

3. <u>The production representation</u>

Basing himself on the primary, acoustical, representation (Representation I), the child must forge a physiological or output representation. Abstractly put, the articulation-perception conspiracy outlined above suggests a cognitive basis for the first production program, whereby all segments are re-categorized in terms of the most stable vowel and consonant. In a paper to the LSA (July 1970, see p.) I suggested a physiological analog to the systemic pressures resulting in what Jakobson called 'poverty of output'; and shall make one or two detailed references to such an analog in passing.

For the moment, let us take for granted exactly how much is produced, for I want to talk first about this second representation, and its improvement, in very general terms.

In producing an utterance, the child registers his attempt. This he does in two ways. He registers the configuration that he reaches, by tactile and proprioceptive feedback--let me call this Representation II. He also registers the external achievement, the sound he produces, by acoustic feedback--I shall call this Representation III.

We may now define the acquisition process in terms of the strategies by which the child systematically experiments with Representation II (his maturing production ability) in order to match his output (III) to the adult model (I).[10] As with initial performance, so with development, we might predict that the perception-production conspiracy will impose a quantum-jump condition--output may approach the model as and when some improved

physiological ability enables the output to be moved one quantum (or some integral number of quanta) towards the model.

I come now to the question: "What is a rule, that a child may know it?" From the first attempted production, there is a new parameter in the child's analysis: the relationship between his own (perceptual and production) representations. Put another way, the child has discovered rules. Could it be the case, now, that these rules define whole-segment substitutions? This is possible, but problematic,[11] for the quantum jump condition on changed representations would seem also to impose a quantum character on the rules relating representations.

So the child comes to have at least three representations, linked by sets of quantally defined rules. There is, too, some evidence that he will retain the two acoustical representations, as well as Representation II. The first (acoustic-input based) is required to account for the cases of such pathologies as laryngectomy or glossectomy (Drachman, 1969), besides the case of mutes (e.g., Lenneberg, 1962): for the former, a fresh Representation II is fairly easily devised, presumably on the basis of Representation I.

The third representation, in turn, will perhaps throw light on three problems:

1. The delayed 'updating' of the output for certain very frequent or affective forms--under the dominance of the 'local' acoustic image.

2. Certain cases of intermittent stuttering--where outputs like "ttt-come" suggest conflict between present Reprreentation II and older Representation III (cf. Stinchfield and Young, 1938).

3. Ability to adapt to local malformation of the tract--i.e., compensatory articulation, here interpretes as temporary change in Representation II, under dominance of Representation III.

With this background, I now propose to match some core concepts of a powerful cognitive model of acquisition, in particular that in Stampe (1969), with what might be their natural analogs in a maturation model. Notice that it is not at all necessary to suppose that the child's progress need be some linear function of his maturing ability to coordinate particular muscle systems. On the contrary, a crucial feature of my account will be precisely that the child devises strategies to diminish homonymy--the whole aim of his linguistic being, may I say!--at points when he cannot yet command the normal (language specific?) modes of articulation for particular segments or contexts.

I take first the notion of rule limitation--of which suppression is the extreme case--then that of rule ordering.

4. Rule systems, rule limitation, and maturation processes

In this section, I shall attempt to reinterpret some simple rule systems as formalizations of maturation processes giving increasing ability to a tract, but taking account of alternative strategies. In the simplest cases, to do this is sufficient merely

to invert the total set of rules and attach to each rule a number representing "months of age" for the child.

Thus, using the convention that the natural (i.e., maximal feeding) order of a pair of adjacent rules is the 'unmarked' order, (1) k to t, (2) t to p, are two simple unordered rules producing p for all k's and all t's. They correspond to the fact that two quantal developments will be needed before p-t-k are distinct (questions of contextual voicing apart), though these two stages need not take noticeably separate periods of time to traverse. The physiological representation (Representation II) correlating to this requirement in the maturation model (Drachman, 1971) is that (1) control of the tongue-intrinsic musculature matures later than that for tongue-extrinsic musculature; thus the first stop is extra-lingual, i.e. [p]; and (2) the tongue tip is the most mobile part of the tongue, and best supplied with feedback receptors; thus, the first lingual stop is [t], rather than [k]. The model only suggests that the overt development will be in this order: as I will later illustrate, individual children may jump stages, and occasionally reverse them.

A more complex example from a somewhat later stage of development is that of the treatment of lateral [l] in English, confining our attention for the sake of simplicity to word-initial position. A typical set of rules (cf. Edwards, 1970), 'unordered' in the sense already mentioned, is:

1. Loss of coronality, giving $\underline{i}^{l}$ (since initial l is [-vel, -Rnd]
2. Loss of laterality, giving $\underline{i}$
3. Strengthening, giving y
   or glide loss, giving Ø.

From the point of view of the production representation (II), the problem here is to match a voiced non-nasal continuant; physiologically, it is to master the simultaneous use of a complex of tongue-intrinsic muscles to produce apical stoppedness and laterality.

First, it is obvious from the substitutions made that the place of articulation is correctly registered. Then for this case too, leaving aside for a moment the question of Glide Loss, inversion of the rule series corresponds to a fairly plausible maturation process, in describing which I shall mention various alternative strategies. At least the palatality of initial [l] is achieved if the tongue tip is turned down, contact with the roof of the mouth being denied to ensure laminar flow and thus preserve continuous voicing. At the first stage, the best that can be done is thus a glide [$\underline{i}$]. The following stages concern the achievement of lateral release [$\underline{i}^{l}$] and then apical contact [l].

Notice, however, that alternatives are available, by sacrificing one or other of the characteristics of [l]. Thus, if the last two stages are attempted in reverse order, apical contact will give a stop [d]: voicing may now be maintained, at least in pre-vocalic position, but continuousness is sacrificed. Alternatively, voicing and continuousness may be preserved easily be velic release, giving

[n]. A last alternative strategy I might mention would be the attempt to preserve continuousness with very close constriction--but note that this produces turbulent flow, with the penality of a greater air-flow requirement and special adjustment for voicing (cf. Klatt et al, 1968), a penalty which probably explains the rarity of the alternative [z].

Finally here, consideration of the gradual mastery of coordinating muscles adds to our understanding of the hierarchy of the environments in which [l] is at length to be correctly articulated. Palatograms of the kind made by Jones (1950) for English suggest that there is a graduation in the delicacy of control for the lateralization process. Control seems grossest for the low vowels and finest for the high vowels--the latter showing minimum lateral release. It is thus predictable that [l] will appear before low vowels sooner than before high vowels.

But even for such a simple case there remain some fairly impenetrable mysteries from the point of view of the "maturation plus strategies" model. One is the question of Glide Loss, producing forms such as [uki] for 'lookie'. It is difficult indeed to see how to account fur such a rule in terms of an 'attempt to pronounce l'. But note that this is the case only if that attempt is inevitably to be thought of as routed through [i] and [y], i.e., if the decision on Representation II is necessarily context-sensitive from the start. Consider again the strategy of setting up Representation II. The child is <u>forced</u> to choose a physiological representation (here, a tongue attitude somehow guaranteeing continuous voicing for the <u>l</u> segment). But suppose he in fact chosses to generalize the <u>velar</u> variant he hears. The (simultaneously chosen) strategy of withdrawal of the tongue tip now of course leaves the blade of the tongue in quite the wrong position to produce an 'accidental' [i] or [i̠], and the following [u] of 'lookie' absorbs the labiality which accompanies velarization. The result is 'zero'.

In such an interpretation, the later appearance of [i] and [i̠] in this word-position would suggest that the child has in fact changed his mind--again, he has made a strategic judgment; this time, that the palatal configuration will in fact reduce homonymy by producing an acoustically closer match to Representation I than he achieved before. I shall offer alternative suggestions for this case below (Sections 5, 6).

5. <u>Rule ordering</u>

It is not difficult to see, at least in principle, that some derivations the content of whose rules speaks to successive limitation or suppression of innate phonetic processes could be interpreted in terms of strategies for taking advantage of (quantal) maturations in articulatory abilities, where 'strategy' corresponds to the use of alternative derivations.

But there is one type of operation proposed by the cognitive model, namely rule ordering (that is, placing of rules in some

non-feeding relation), which it is much harder to find an analog for, at least in terms of the maturational part of the model I am considering. I shall first argue that certain putative examples of rule ordering are to be explained otherwise. I shall then perforce face the higher mysteries again.

5.1. The case of 'choo-choo'

At 19 months, Hildegard Leopold has forms like 'juice' = duš, etc., as well as a solitary form in č-, 'choo-choo' heard once as dudu. The two simple unordered rules, 1. č → j and 2. j → d cover the facts. At 20 months, however, she has 'juice' = du(i)š still, but now 'choo-choo' = čučų or jujų, mainly the latter. Here we seem to have to do with the ordering of rules, the unmarked order (1, 2) producing the earlier forms, the marked order (2, 1) the later ones.

However, notice (1) We are dealing with a single form here (the form for 'church' was acquired later (at 22 months, only in a nursery rhyme), and already had [j-] in its first shape). (2) It is not clear from the account in Leopold that the early form [dudu] in fact corresponds to 'choo-choo' at all--rather than, say, to 'toot-toot'. (3) At 26-28 months, newly-acquired 'cheese' is [diš] and 'chubby' (name of a doll) is given as [dʌbi].

For this case we must thus reserve judgment, since it is unclear whether the examples in fact show us the child ordering rules in order to distinguish segments merged by the unordered rules. I shall discuss below (section 6) the importance of the paucity of examples.

5.2. 'Puddle' and 'puzzle', and other puzzles

A clearer suggestion that we may not constrain our model to handling simply articulatory ability is apparently offered in cases like that in Neil Smith (1970), where at 31 months 'puddle' gives [pʌ́gəl], while 'puzzle' gives [pʌ́dəl]; that is, the three ordered rules: (1) velarize final l; (2) coronal, non-cont → velar before velar l; and (3) coronal cont → stop, account for the data. It seems confirmed that "...the sequence [pʌ́də] was completely within the performing capabilities of the child, but he was incapable of applying it to the right adult form because of the pressure of his rules." (Smith, 1970).

Now rule 2 needs an explanation. Why, in fact, does velar harmony operate for stops but not for spirants?[12] Perhaps it is because, while a spirant by its nature is released, the homorganic stop is in fact not separately released before [l]. But note too that, even granted that the difference in treatment of underlying spirants vs. stops in thses cases can be thus explained, we must still apply the rules 2 and 3 in the order given, rather than in reverse, unmarked order; otherwise a merger will occur, and 'puzzle' will also appear as [pʌ́gəl].

Similar cases can be adduced from the Leopold data, for voiced and voiceless stops. Thus,

1. while final t appears at 22 months, final d is always lost up to 24 months.

2. while initial k sometimes appears as k (rather than d) from 18 months, initial g always appears as d up to 24 months.

Underlying voiceless stops, it seems, are produced correctly for voicing and place before the corresponding voiced stops are. Whatever the physiological explanation for this, the word "underlying" in the above statement is crucial, i.e., the processes apparently do note take place in the tract, but are to be considered essentially mentalistic in nature.

5.3. Ordering and homology of articulation

The third (and most important) case I want to discuss is from Velten. Assuming that at 15 months 'lamb' = bap and 'up' = əp, then the two rules (1) m → b, and (2) b → p are seen to be unordered, i.e., in feeding order. However, at 22 months, we see that 'broom' = bub, and 'train' is dud, while 'bed' is but, from which it might be deduced that rules (1) and (2) had been ordered, that is, placed in a bleeding relation.

I want to deal first with the problem of voicing in final stops and nasals.[13] I shall then re-appraise the relevance of this example to the problem of rule ordering.

Notice that for Velten's child nasals are first produced word-finally when preceded by the vowel [a]. This is simply explained in terms of the sluggishness of velum control at the early stages. Since the velum must raise for an obstruent whose closure is further forward in the tract, but may be open for a vowel (the degree of opening being inversely proportional to the height of the vowel), it is clear that the optimal condition for velum lowering in a final nasal obtains when it is preceded solely by a low vowel, by another nasal followed by a low vowel, or by h followed by a low vowel.

At 22 months, we see the optimal condition fulfilled, as in 'arm' = am, as well as in forms in ha- such as 'ham' = ham. The assimilations for θ and l in 'thumb' = nam and in 'lion' = nan likewise fulfil this precondition.

With this background, we may look again at the crucial forms; in short, while 'bed' = but, 'jam' = dab and 'home' = hub. I now suggest that final [b] from [m] no longer merges with true [b] for the simple reason that the 'nasal' [b] is at this stage precisely that, viz., a stop whose voicing is aided by velar leakage. Meantime the pharyngeal widening which accompanies voiced stops in adult language (cf. Rothenberg, 1968) is presumably yet lacking--so that final voiced stops are still unvoiced.

At 24 months, Joan Velten masters whatever mechanisms are required for voicing in final stops, while nasals continue to be fully nasal only in the protected conditions mentioned. The last stage, probably involving full mastery of the velum, comes at 30-33

months, when final and then medial nasals are at length correctly pronounced in unprotected environments too, e.g., where preceded by a stop or spirant as in 'apron' = u.pin, 'farmer' = fa.ma.

At first sight, the moral of this story, though important, seems negative. We might assert that, since it is a case of non-homologous outputs (that is, outputs that merely sound alike[14] though quite differently produced), this case is simply not relevant to the problem of child rule ordering.

But I wish, on the contrary, to suggest that non-homologous production is in fact one of the mechanisms by which the need for rule ordering may actually be circumvented. At a point where massive homonymy obtains through the merger of m, b, and p, a temporary strategy has been discovered, making use of the developing mastery of the velum, to distinguish at least underlying m from b-p--though the hierarchical nature of the control dictates that this can only be successful in certain specifiable environments, viz., the protected ones in the above account. As soon as both the stop-voicing mechanism and the velum are finally mastered, however, all three segments are automatically disambiguated.

Numerous cases are cited in the literature (e.g. the examples from Smith, above) where, despite the fact that mastery of the pronunciation of a given segment has not been achieved, yet an apparently identical segment appears in the function of a substitute for some other. I now suggest that most if not all of these will prove to be cases of strategic non-homologous articulation[15]--cases, that is, not of rule ordering, but in fact of the circumvention of rule-ordering.

Confirmation for the position I have taken on homology is partly provided in a study of the production of initial consonant clusters in children from 18-34 months by Menyuk and Klatt (1968). For an intended production of 'Brian', the time from the release of the stop to the steady state for the [a] vowel is longer than in 'bike'. The authors point out that "an adult listener will not hear an [r] when presented with the word intended to be 'Brian', but...it is likely to believe that some kind of phonetic segment is interposed between the [b] and [ai]. This segment is acoustically most similar to a [w]."[16] It is thus most important to elucidate the facts of child articulation in such cases, with the aid not only of spectrography (compare Kornfeld, 1971) but also with continuous palatography, EMG and X-ray cinematography.

From scattered remarks in the literature (e.g., Preyer, 1914: 107, and Jesperson, 1922:104), it seems likely that the problem of homology will prove the more acute as it is examined for younger and younger children.

Comparing the case of Hildegard Leopold, we see now the expected variation between individual strategies. Like Velten, Leopold produces true nasals before producing voiced stops in final position. Unlike Velten however, Leopold 'acquires' not only final nasals in protected and unprotected forms alike, but even nasal + stop clusters, before acquiring final voiced stops. The similarly expected differences in overall time of development

of course apply too. Thus, while final nasals begin to appear for Velten as early as 16 months, for Leopold no final nasals appear until 26 months--the first, incidentally, being the velar nasal.

Notice that a common strategy, at least for English speaking children en route to the distinction between final voiced and voiceless stops and spirants, is to halve the homonymy by lengthening the vowel before the underlying voiced members of these pairs. It is easy to predict that the apparently non-distinctive feature of length will usually be attempted before the apparently distinctive one of voice; whatever the command system for voicing finally turns out to require (cord adjustment, larynx lowering, pharynx laxing, or some complex of these), it is clearly simpler to continue an already given command (that for voicing, plus the configuration for a vowel) than to switch commands. It is equally obvious of course from the gross over-length of vowels recorded (cf. Naeser, 1970), that we have here to do with rule-guided behavior, rather than mere imitation of vowel length.[17]

6. The strategy of avoidance

In my discussion of perception I referred to the possibility that, at least so far as the labiodental and interdental fricatives are concerned, the absence of illustrative forms from the corpora is more than an accident, and suggested that it is in fact connected with insecure representation at the primary (acoustic) level. I now consider other evidence and implications from silence.

In discussing the development of voiced stops and nasals in final position in the Velten data, I noted that at the time (22m) when nasals sounded like voiced stops, underlying voiced stops were unvoiced. For the earlier stage, I now want to point out, the only form supporting the rules implied here is the form for 'lamb'--and in fact no example of a word containing an underlying final voiced stop appears before the crucial 22nd month. Since there must be many words ending in voiced stops known to the child, it is tempting to suppose that such words are in fact being avoided by the child--in this case, I surmise, avoided until a strategy can be devised to distinguish nasals from voiced stops, i.e., to undo some of the massive homonymy obtaining.

The parallel strategy in Leopold refers to initial consonants, in particular, to palatal stops. Consider the following common forms probably known to a small child: (a) chocolate, chair, Chuck (name), cheese: lunch, touch, scratch, catch; (b) juice, Johnny, jam, jelly, jump, June: huge, cage, bridge, change. The absence of forms, e.g., in initial [c] for the whole of the first 24 months suggests the strategy of avoidance again--avoidance of honomymy with the product of [ɟ] in initial position.[18]

Let me revert now to the problem of initial [l]. In the light of the above argument, it is perhaps not wholly foolhardy to suggest that the 'zero' exponent of an underlying initial [l] may prove an example of a strategy which I shall call 'local avoidance':[19] and if that is a possible case, then surely so too

may the (so-called) deletion of initial spirants be one--as an alternative strategy to total avoidance of the words containing them.[20]

Now there are important implications from such avoidance (apart from the implication for methodology).[21] First, much avoidance may be interpreted as total suppression of forms for which certain kinds of rule-ordering are to be performed--though it remains to clarify how to distinguish these from cases where homonymy is tolerated in the output.

But this of course implies that the rule ordering will proceed before the corresponding forms are produced--that is, proceed purely mentally.

It is also reasonable to claim now that, since we shall in any case not witness certain stages of development (the cases of rule ordering for which forms showing the unmarked order are totally suppressed), there may well be further stages of all derivations for which no overt evidence will appear in the corpora--the quantum changes again occurring mentally.[22] This removes an important kind of constraint on the rules we may write to correspond to the proper derivations of forms: in particular, such considerations seem to support the claim that the rules ought to recapitulate the strongest form of the 'quantal change' hypothesis we began with. That is, every derivation must in principle be fully quantal, regardless of the absence of illustrative forms in the corpora.[23]

7. Conclusions

To sum up, this paper offers various kinds of data that explicate or modify the cognitive model for the acquisition of phonology suggested by Stampe. I cited evidence to suggest that segmentation and featural analysis are tools available to the very young child, and that there is reason to suppose that at least his acoustical representation substantially matches the surface adult shapes. In offering an account of the acquisition of multiple representations, I claimed that the notion 'phonological rule' could be simply reconstructed as a relationship between certain such representations.

I also examined the possibility of reconstructing the notion 'derivation', by re-interpreting rule derivations and the limitation and suppression of rules, in terms of hierarchies of alternative strategies for the use of maturing coordinations of muscle-systems.

Finally, I discussed two strategies by which the child may begin to resolve the massive homonymy in his output without resorting to rule-ordering in the early acquisition period. Some ordering problems are circumvented by the simple device of avoiding words containing one of the merging segments; others, by the adoption of a non-homologous articulation for at least one of the merging segments--so that in both cases later maturation (corresponding to simple limitation and suppression of innate rules) will undo the rest of the homonymy.

Footnotes

1. This paper will appear in the Proceedings of the Urbana Conference on Phonology, held in April 1971.

2. Techniques of this kind could perhaps be used to test for memory of the content of unstressed syllables during the early acquisition period. Does the child, in fact, attend only to the stressed syllables?

3. Better (pace Ladefoged, 1959:416) as syllable onsets in initial position.

4. f initially only when supported by f-final, in 'faf' (the name of a dog) "after assiduous practice," so za 'that' (12m) does not even partially contrast with initial f.

5. Preyer's child was still confusing 'Ofen' with 'oben' (he would look up, asked to indicate the oven) at 20m. It is interesting that the interpretation with -b- dominated: it suggests that the "stable articulation point" concept might account for some perceptual and production substitutions.

6. A view entirely in accord with that of Stampe (1969). For doubts, cf. that in Kornfeld (1971). The cases are by now legion where forms not heard or produced by the child for some time are later produced in a form fully updated according to the later system.

7. Consider how much later the relevant data for reconstructing such rules as tri-syllabic laxing, velar softening, spirantization, or vowel-shift is 'available' to the child. Many pairs such as critical-criticize, etc., are required before the child is forced to reanalysis.

8. Stevens and Klatt (1971) suggest that the presence or absence of a well-defined F1 transition following the onset of voicing is an even more primitive cue than VOT, for the infant with little previous exposure to speech. In this case, the Korean child would have (a series of) three strategies at his disposal in perceptual analysis.

9. This seems an entirely verifiable hypothesis. The environments not under rule-government should show greater individual production variation--from instance to instance of the same utterance--for the same person, or from person to person.

10. By definition, then, the child is very early aware of his deviant pronunciation--and must be so, if he is to improve it (Cf. Gutzmann (1894), but also the opposing view in Delacroix (1924)).

11. The attractiveness of such a hypothesis is simply that it suggests a reconstruction of the notion 'derivation' in terms of the acquisition process. Derivations, in this interpretation, would arise during acquisition, with the (quantum-wise) approach of the production representation to that of the model--as also indirectly suggested in Section 4.

12. Spirants do not appear in the Smith corpus for 26m. The delayed mastery of the delicate articulatory control of spirants is predicted by the maturation model (Drachman, 1971).

13. I choose the position giving greatest homonymy in output. It is clearly predictable that initial nasals will present no production problems--even if the velum tends to be raised as part of the speech-ready configuration, an initial nasal command will inhibit the raising very easily.

14. Cf. Jespersen (1922).

15. In regard to the zero exponent of initial [l], which bothered me earlier--here too, it might well prove that what is acoustically zero is in fact represented by some weak articulation, by definition non-homologous with zero.

16. The production-perception conspiracy of course emphasizes this: any stimulus identified as a segment will be assigned to the 'nearest' segment.

17. For an account of the intimate way in which vowel length is related to voicing of following (final) consonants, see Drachman (1970b).

18. Confirmed from the shapes of the two putative examples, both showing 'support' for initial č later in the word. A topic probably worth investigating in this regard is that of avoidance of one or other of a synonymous pair: better yet, choice of words, for children in bilingual environments (cf. Leopold Vol. II, paragraph 497).

19. In partial mitigation of the ad hoc appearance of such a strategy, consider the following interesting case from Sanskrit of a consipracy concerning -l (Zwicky (correspondence to Lakoff, Dec. 1968)). (1) No root ending in [l] belongs to an athematic verb class...(a class for which the initial dentals of many conjugational endings would then immediately follow l-), (2) No root shows a sequence such as l + dental, and (3) If a derivational process brings together a root-final -l and a suffix-initial dental, the union-vowel [i] is inserted.

20. I do not at this point want to suggest that cases of loss of <u>final</u> consonants have anything to do with 'avoidance': I can only suppose, for the latter, that a constraint on syllable structure is operative.

21. The implication for methodology is important too. Before we can clarify the hierarchies by which homonymy is tolerated in attempted outputs, systematic recordings must be made not only of outputs but also of comprehended forms, so that we may sharpen the notion 'avoidance strategy.'

22. But again, it is not clear how much <u>overt</u>--though sometimes secret--practice may be involved (cf. Weir, 1962). According to the present model, some children suppress nearly all forms until they have, as it were, ordered the rules correctly--these are 'late' speakers whose very first productions show comparative maturity of phonological structure.

23. Which of course flatly contradicts the hypothesis of footnote 10 regarding the interpretation of the first production representation as containing <u>wholistic</u> rather than quantally defined) substitutions.

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Studies in the Acquisition of Greek as a Native Language: I. Some Preliminary Findings on Phonology[1]

Gaberell Drachman and Angeliki Malikouti-Drachman

Abstract

This paper discusses some preliminary findings from a 'pilot' study of the acquisition of phonology by normal Greek children in a monolingual environment in Athens, Greece, and draws on data elicited by the authors during the summer of 1971 from children of from 24 months to 9 years of age.

The five topics treated concern (1) the problem of observational adequacy in the transcription of child language, (2) the developmental disruption of the syntactic function of suprasegmentals, (3) the 'primacy' of the labial stop, (4) child speech-production and the migration of Features, segments, and syllables, and (5) the acquisition of external sandhi and the reinterpretation of the Greek stops.

1. The problem of observational adequacy in the transcription of child-language

Fairly frequent and sometimes glaring inconsistencies in transcribing from the same tape from one day to the next have convinced us that we have no adequate orthography for child language, but also that there is a serious problem--one on which there seem to have been few experimental studies (but cf. Menuyk and Klatt, 1968; Kornfeld, 1971)--in the adult perception of child speech.

Both Peterson and Barney (1952) and Lehiste and Meltzer (1971) did in fact include child vowels in their investigations--although those studies were conducted for other ends than the direct investigation of adult perception of child vowels. Analysis of the Lehiste and Meltzer data in particular shows that adult listeners may seriously mis-label certain child vowels listened to in isolation; thus [i, ʌ, and ɜ] are often heard as [u], and [u] is often heard as [a], misidentifications which can hardly be dismissed on the ground of dialect differences between speaker and hearers.

Now while it is quite unclear why perception tests should give such results, we have for the moment the fact that vowels vary a great deal in their relative identifiability, the more so when an adult identifies a child's vowels; and we must wonder, correspondingly, whether a child's consonants are in fact any more easily identifiable to an adult. The problem may be compared to some extent to that of listening to a strange dialect or foreign language, and is to that extent parallel to the problem of what

happens to loan words: the heard segments, both in their own right and in their sequential relations, are interpreted and stored in terms of the morpheme structure conditions and phonological rules of the listener's language (cf. Hyman, 1970). However, the added, and perhaps the most important dimension here is that there is also the assumption of homology of production: should this assumption prove unjustified, the misidentifications of child segments by adults would be unpredictable in any systematic sense. It is important to note that such an outcome would seriously call in question the possibility of showing that any particular heard child substitution in fact bears a particular rule-relation to the putative corresponding adult segment.

2. Developmental disruption of the syntactic function of supra-segmentals

It is well known (e.g., Lieberman, 1967; Kaplan, 1970) that the child responds early to suprasegmental qualities of speech such as intonation and emphasis. Thirty-three month old Maria had learned by heart a seven-line poem. Now while it is unlikely that she understood the meaning of the poem at all well,[2] Maria delivered it with near perfect preservation of the rhythm, intonation and syllabication.

We contrast this with the case of Elena. At 42 months old, Elena is very far ahead of Maria in general speech ability, at least so far as production is concerned; Elena chatters quite intelligibly all the time, and can converse in quite complex sentences of some length. Yet she has run into serious trouble in her control of breath-groups and intonation. This shows itself in at least five ways, as follows.

1. ...apotisérikas inafto → ...abodizérika zínató

   (It's one of Erika's)

2. ...psínete mésa sti lekáni → ...bzínede méza sti lekáni

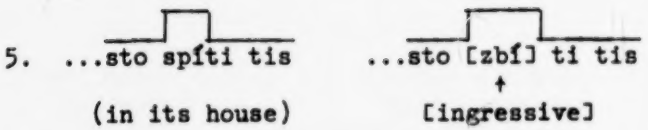
   (It's cooking in the basin)

3. ...ðéŋgzero pos to lene → ...ðéŋgzero pos to léne

   (I don't know what it's called)

4. ...sto aristeró se túto → ...sto aristeró su túto

   (on the left one, on this one)



She may fail to lower the pitch on an unstressed syllable, as in sentence (1). Alternatively, she shows pitch assimilation of a word-final unstressed syllable to a following stressed syllable, as in sentence (2). Pitch frequently rises in sentence-final position in declarative sentences, as in sentence (3).[3] Pitch contours may even break across constituent boundaries: in sentence (4), not only has the preposition se been moved into the following constituent, but its vowel has undergone assimilation to the stressed syllable of the following deictic túto.[4] Finally, as sentence (5) illustrates, Elena sometimes speaks syllables, words, or even whole phrases on ingoing breath--in her desperate attempts not to break across syntactic units to take breath.

It is apparently the case that, as for other abilities in the growing child, maturation problems can arise for the suprasegmental qualities of speech: though determined semantically and syntactically, the intonation and stress patterns may at some stage of integration not conserve constituent structure as they did earlier (as in the case of Maria's poem) and will again later in maturer speech.[5]

3. On the primacy of the labial stop.

During the acquisition period, children characteristically pass through a short period when the only stop they can pronounce is p. On the basis of the commonness of this phenomenon, taken in conjunction with the psycho-physical and acoustical theories of Stumpf and Köhler, as well as data from aphasia, Jakobson (1941) proclaimed the priority of the labial consonants and the a-vowel, a priority re-asserted in Jakobson-Halle (1956).

With the advent of generative phonology in the 60's, the moderating claims of developmental physiology advanced by scholars such as Leopold (1947) were soon quite overlooked, and psycho-linguists continued to accept the Jakobsonian hypothesis as dogma. In particular, no serious attempt was made to explain why, if the systemic pressures were so very strong, there should ever be exceptions at all.

Consider the data for the child Maria. At 33 months, Maria had t/d for most instances of adult p/b (1a below) and k/g (1b below), despite the presence of m (1c below). The few examples of labials or velars occur in very constrained environments (2-3 below), environments which--perhaps not coincidentally--are largely common for the two stops.[6]

1.	a.	pétros → tétos	(Peter)
		pirúni → tulúni	(fork)
		paráθiro → talátilo	(window)
		kanapé → tanaté	(couch)

	b.	eḱíno → etíno	(that one)
		kumbíá → tūdá	(buttons)
		psematáḱ̟a → tematáta	(lies)
	c.	mitúla → mitúla	(nose)
		psematáḱ̟a → tematáta[7]	(lie)
2.	a.	bébis, babá, pipí, pópi, papá, papíta	(baby, daddy, dress, Popi, shoe, "Papita")
	b.	kokoríkos → kokolíkos	(cockerel)
3.	a.	epiǿí → epilí	(because)
		periméni → peliméni - teneméni	(he waits)
	b.	sḱiláḱí → ḱiláḱi - tiláḱi	(puppy)
		karékla → kaléta	(chair)
		xalí → kalí	(carpet)
4.	a.	píta → píta	(pie)
		sayapó → tadapó	(I love you)
	b.	ǿéka → déka	(ten)

At least two (mutually exclusive) explanations suggest themselves for this data. The first is that Maria indeed had p and even perhaps k at an earlier stage, that massive Dentalization has recently occurred, and that the instances of p and k constitute 'survivals'. As a sub-alternative, one might even suppose that Dentalization is not one rule but two--consider languages like Tillamook and Tlingit, which lack labials; and the Slovenian dialects of Carinthia which (Jakobson 1941 informs us) lack velars--and one could imagine the coincidence whereby Maria has adopted both rules.

But the opposite explanation is equally viable, viz., that Maria did not in fact have p or k at an earlier stage, even though she had m--and that the instances of p and k thus constitute 'emerging' environments for these segments.

The late appearance of k is of course not what is unusual: it is the absence of p, the archi-stop--in fact, the archi-consonant. Yet it may well be that the archi-status of p has been exaggerated. Certainly, a physiological model for phonological acquisition (e.g., Drachman, 1970) need give the tongue-tip closure no lesser status than the bilabial one--the tongue tip is indeed a very flexible and fast-moving organ, well endowed with feed-back fibres. Further, it is clear that what is in fact never lacking in the languages of the world is (not p, but) t.

We hazard the speculation, then, that t is at least the alternative and co-equal candidate for archi-stop with p. In reply to the question, which obviously follows, why there are not frequent cases in the acquisition literature of t as the first stop,[8] the

following brief data are offered from Preyer (1889), Sigismund (in Preyer, 1889), and Taine (1877), in the belief that those were perhaps not the only examples before the case cited above.

Preyer: 14 months; mama, papa → ta-taĭ
15 months; away, gone → atta, ha-atta

Sigismund: to 16 months: papa, Ida → atta

Taine: 14 months, 3 weeks; papa, tem (first words)
also: mama, mia, wawa,
tete, dada
koko, kaka

4. The migration of features, segments and syllables in child speech-production

The central issue in child phonology has always been held to be the problem of systematic substitutions, a question that arises again seriously in the study of adult speech perhaps only for aphasia and certain speech defects. But there are aspects of speech production seen in exaggerated form in child speech which in fact recur--though only sporadically--in the speech of all normal adults. These sporadic instances of "take-over" by the tract are for adult speech known as 'slips of the tongue' (cf. Fromkin 1971) and are of two types. First, the anticipatory and inertial forces of co-articulation induce varying degrees of vowel and consonant assimilation (called Harmony). Second--though this may prove to be a special case of the discontinuous domain of the first type--the migration or copying of Features, segments, or even syllables, gives rise to metatheses often called Spoonerisms. Our data offer interesting varieties of both types for child language.

4.1. Vowel harmony

In the ongoing vowel gesture which has been held to constitute the substratum of the speech production process (Öhman, 1966; Perkell, 1969) we expect the unstressed vowels to be dominated by (and thus to assimilate to) adjacent stressed ones, whether by anticipation or inertia. This seems to be the physiological basis of vowel harmony in languages of the world, and we expect it to be an especially prevalent process in child language.

Examples are abundant up to the ages of 30 months or more, but there are some unexpected details.

1. stoḿa → otómo (mouth)

2. kuneláḱi → kulaláḱi (rabbit)
xeliǿóni → tololóni (swallow)

3.	fórema → lólama	(dress)
	ɣarífalo → kayíkoko	(carnation)
	síɛ́ero → lítoto	(electric iron)

We find assimilation by anticipation to be the rule, although a rare case of inertial assimilation may be seen in the final vowel of 'mouth' in (1) above.[9] Second, we find only rare examples in which the immediate domain of the stressed syllabic extends beyond one syllable--compare 'rabbit' with 'swallow' in (2) above. Third, it is not always the case that the stressed syllabic dominates--although it is usually true that an unstressed syllabic dominates only another unstressed one, as in the examples under (3) above.

At first sight, certain forms in the corpus for Thanasis (30 months) seem to contradict the claim above; i.e., they apparently illustrate the anticipatory assimilation of a stressed vowel under the dominance of an unstressed one, as in 'door', 'tongue', 'macaroni', and 'please' in (1) below.

1.	pórta → páta	(door)
	ɣlósa → ɣʊlás	(tongue)
	makaróni → makaRán	(macaroni)
	parakaló → parakalá	(please)

Now this phenomenon occurs for Thanasis only with adult stressed [ó]. What is more it occurs also in the forms 'poor', 'at Lemos' (in (2) below), where the change to [a] can certainly not be attributed to vowel harmony, since the unstressed vowel is not [a].

2.	ftoxós → toxás	(poor)
	sto Lemó → sa Lemá	(at Lemós)

However, when we compare also the forms for 'knife', 'hand', and 'teapot' ((3) below) it is clear that we have to do, not with an unrounding rule--as we might suspect from the forms in (1) and (2)--but with a more general rule lowering both mid-vowels under stress.

3.	maxéri → maxɛ́ri	(knife)
	xéri → xɛ́ri	(hand)
	tˢayéra → tˢayɛ́ra	(teapot)

Note how context-sensitive such a tendency is in child language: the lowering occurs only when [ó] is in a final syllable or when its syllable is flanked by syllables containing non-high or non-round vowels.[10] Even then, its optimal environment--seen for the front vowel--appear to be the adjacency to [r], here apparently behaving as a laryngeal.[11]

This analysis also disposes of some apparent cases of inertial assimilation for unstressed vowels, ((4) below) where unstressed [o] seems liable to lowering almost <u>only</u> in the optimal

environment--adjacency to [r].

4.	ɣáɟɗaros → ɣáɗalas	(donkey)
	kókoras → kákalas	(cockerel)
	ɗéndro → ɗɛ̃ʔⁿdəh	(tree)

With a preceding stressed front vowel, on the other hand, [o] undergoes partial assimilation and is centralized to [ə], as the forms of (5) below illustrate:

5.	θíos → sía	(uncle)
	kléo → kléə	(I weep)
	píso → píse	(behind)

The (five-vowel) Greek vowel system is a very simple one, compared with that for English. The present analysis shows that the child's route to the mastery of such a system may be more complex than that comparison suggests. It remains to be seen, however, whether the appearance of such a lowering rule is at all common during the acquisition of phonology by Greek children, or whether it is an example of individual variation.

4.2. Consonant harmony

While the most (developmentally) primitive form of consonant and vowel assimilation is the repetition of identical open syllables, we note that the inhibition of this dominance occurs first with the vowels; thus, consonant assimilation goes on later than does vowel harmony, and has more far-reaching results.

1.	filipáki → papáki	(Philipaki)
2.	ɣála → lála	(milk)
	luluɗáki → lululáki	(flower)
	makaróni → mamaróni	(macaroni)
3.	ɗaŋgóni → gagóni	(bites)
4.	búka → gúba	(mouth)
	tsuŋgrána → gudána	(rake)
5.	laɣudáki → ɣulaváki	(rabbit)
	mikrófono → konítoto	(microphone)
	tsekúri → kutíəli	(axe)

For Chrissa (27 months) we see the name Philipaki as the last relic of syllable reduplication, in (1) above. Of course, this form might also be subsumed under a putative labial harmony--and we would thereby logically also set up Lateral, Nasal and other harmony types for forms such as those under (2) above.

Under (3) and (4) above are given forms illustrating so-called velar harmony. But there are complications: while for 'he bites'

the single process velar harmony is invoked (cf. gogi for English 'doggie') for 'mouth' and 'rake' two processes are to be supposed--thus, velar harmony for the initial dental, then dissimilation for the second velar (as with the alternant godi for English 'doggie').

However, consider the forms under (5) above. At first sight, these too are candidates for velar harmony. But it would in fact require quite ad hoc rules (one per form) to adjust the output of the velar harmony rule to produce the correct forms. For instance, if layuɠáǩi (rabbit) becomes yayuɠáǩi by velar harmony, simple velar dissimilation ought then to produce (incorrect) yaɠuɠáǩi, giving (equally incorrect) yavuváki--since interdentals give labio-dentals for this child. Noticing that the vowels as well as the consonants are switched in place, we suggest that this is really an example of syllabic metathesis.

Similarly, if tsekúri 'axe' became kekúri by velar harmony and then ketúri by velar dissimilation, it would still require either a complex set of further assimilations or a switching rule to adjust the vowels--and again, syllabic metathesis is much the simpler solution.[12]

4.3. Prompted recall and 'slips of the tongue'

In interviewing children we were sometimes driven to prompt them, either to elicit a single utterance of a given word, or to elicit a repetition of (say) a mumbled one. We soon noticed that a second prompt following the child's prompted attempt often produced yet a second variant, and so on. On occasion, as many as eight variants were elicited in this somewhat maddening fashion, as the entry below under 'electric iron' attests.

1.	psiyío	Spontaneous	sibío (refrigerator)
		Prompted	piyío ~ tiyío ~ s.kíp+to
2.	elvetía	Spontaneous	eveltía (Switzerland)
		Prompted	evletía ~ evetía ~ veltía ~ elveltía
3.	síɠero	Spontaneous	lítoto (electric iron)
		Prompted	lítoRo ~ ?lít?oRo ~ yíoɠo ~ líovo ~ yíyelo ~ yíyado ~ yíɠolo ~ ǩí-ɠé-Ro
4.	pondikáǩi	Spontaneous	kolíkoko (mouse)
		Prompted	gokabé.to ~ gubadáki

The reason why we persisted in this sometimes painful technique is simply that we realized that we could thus watch the operation of the child's Distinctive Feature system. A few preliminary remarks are in order, pending fuller analysis child by child.

First, not only segments but also single Features may migrate across words. The spontaneous form for 'refrigerator', sibío shows this; the stopedness and bilabiality of the initial [p]

migrate to the place of the medial [y], but take on the voicing of the latter. The prompted alternant tiyíó in turn suggests that the same cluster may also be resolved in a segment taking the stopedness of the [p], but the place of articulation of the [s], thus, [t].[13]

The second form, 'Switzerland', shows the metathesis of single segments, as well as generating the suspicion that metathesis will sometimes operate by a copy-and-delete procedure, the copy stage of which is seen in the variant elveltía.

The forms for 'electric iron'[14] and 'mouse',[15] the complexities of which are not entirely clear, seem to involve mixtures of metathesis and assimilations.

Now it is not obvious that the construction of Feature-confusion matrices (e.g. Wickelgren, 1966;[16] Klatt, 1967) would in the least illuminate the problems in forms such as those cited here, and one is tempted to conclude that the multiple processes involved may be recaptured only by series of ordered rules. But then neither is it obvious what is really implied by this latter claim either, for the cases in point; after all, the sets of processes we must postulate are hardly regular,[17] as the fact of variation itself demonstrates.

Whatever the analyses, they must in the end account for the relation disclosed between sporadic processes in child language and similar processes, though surfacing much more sporadically, in adult 'slips of the tongue'.

4.4. Pronunciation improvement and intervention.

Although it was never our intention to attempt to improve the pronunciation of the subjects by repeated prompting, improvements did on occasion occur. It is obvious, however, that no systematic advance in pronunciation accompanied these word-specific improvements; on the contrary, even where the same word was elicited again later, a uniform regression to the first spontaneous shape was evident.[18]

It will be of interest, to take a rather weaker prediction, to see whether an 'improvement' foreshadowed (as it were) under prompting does in fact appear systematically shortly thereafter--as claimed, for instance, by Smith (1970).[19]

5. The acquisition of external sandhi and the reinterpretation of the Greek stops

It is reasonable to hold that the child's earliest perceptual representation of any given word of his language may well be a good deal less abstract than the one he will later require in order to account for complex relationships between certain sets of consonants or vowels--consider the consonants in the set corrode--corrosion-corrosive, or the vowels in the pair telegraph-telegraphy--and that the abduction of the appropriate

relational rules must be accompanied by the reinterpretation of the relevant segmental representations.

At a more nearly surface level, we shall hold for Greek that it is the proper operation of the rules for enclitic sandhi that in fact force the child to reinterpret his representation of the voiced and voiceless stops. But first, some facts about enclitic sandhi in Greek.

Taking only the simplest case,[20] Greek shows external sandhi between the final nasal of the Accusative enclitic particle and a following voiceless stop or continuant. The processes involved are simple, perhaps even universal tendencies of the vocal tract: the nasal is 'lost' before the continuant; with a stop, however, the nasal assimilates its point of articulation to that of the stop, while the latter assimilates to the nasal for voicing. Thus, using male names as examples:

Nominative o Pétros, O Tásos, O Kóstas, o Vàsilis, O Làkis
but Accusative tom betro, ton dáso, toŋ gósta, to vasíli, to láki

Part of the process of learning the rules will of course involve learning the constraints on them:[21] the point at issue here is that the child must modify his representation of the stops if the rules are to operate at all, with minimal effort on his part.

The aspiration noted sporadically in the early production of voiceless stops be Greek children strongly suggests that the stops are Tense;[22] and this is probably the direct explanation of the child forms corresponding to the above, for the early stage, i.e.,

Accusative: to pétro, to táso, to kósta, etc.

The tense stops will of course fail to assimilate to the preceding nasal for voicing, and will in fact provoke nasal-disposal only slightly less surely than will the continuants.[23]

Our data show that some children have not completely mastered the adult sandhi rules even by the age of nine years. Clearly, however, from the time at which sandhi operates at least to the point of voicing a stop following a nasal,[24] we must assume that the relevant stops are Lax in articulation.

Now it may be argued that, while the representation of the rule-affected segments must be modified under the kind of rule-pressure exemplified by external sandhi here, the same segments in non-rule-guided environments are free to take the proffered 'free ride' or not.[25] In the present case, the child hears and now performs m+p as giving b or m+b in external sandhi: he is now free, it is suggested, to reinterpret those cases of morpheme-internal [mb] which alternate with [b], as underlying /mp/. Does the acquisition data support this notion?

Take first a child not yet producing sandhi-affectable forms at all. Chrisa has at 27 months only single-word utterances, and

thus of course only uninflected nouns; for her, then, the voiceless stops might have been Lax, or Tense, or even Tense and aspirated. She seems to have chosen Lax, however, as is seen from the fact that initial stops sometimes voice through, as in

pórta → bóta (door)

But note that Chrisa has certainly not yet reinterpreted medial [mb] as /mp/: for lámba 'lamp', she also has lá·ba, where the disposal of the nasal by assimilation to the preceding vowel has stranded a b, not a p.

Thanasis, older by three months, shows sandhi of the most advanced type, as in the correct stiŋ guzína (in the kitchen). As predicted, he also seems to have reinterpreted word-internal [mb]; this is strongly suggested by his treatment of sómba (stove), which shows nasal disposal by vowel assimilation leaving a stranded p, in sá·pa.

On the other hand, the 40-month-old Alexis has clearly not yet reinterpreted his word-internal stops--as is seen from the form ʝekapé·de for ʝekapénde (fifteen) with stranded d after nasal assimilation--despite his use of sandhi. But in fact his sandhi shows the alternation of Tense and Lax for the voiceless stops, as in

Accusative ton dáso → to dáso ~ to táso (Taso)

an indication also evidenced in his occasionally aspirated stops, as in

ɣatúla → ɣat^{h}úla (kitten).

Within the framework of the present argument, the only sure evidence adduced for word-initial reinterpretation of [mb] as /mp/ has been the occurrence of a stranded voiceless stop with lengthened preceding vowels. But the occurrence of medial N plus voiceless stop would of course be equally convincing; and Michael, aged 8 years, shows just such a form in

yígandos → yígantos (giant).

The acquisition data thus seem to support the view that it is the rules for enclitic sandhi that force the child to reinterpret the stops of Greek. This reinterpretation is at first applicable only to word-initial stops (the rule-guided environment), but probably begins to be fully mentalized and thus extended to word-medial stops[26] fairly early in the acquisition process, though at quite individual rhythms from child to child.

A last comment concerns the child's treatment of 'loan words'. Vasiliki is over 7 years old, and so far as 'native' words are concerned her data show assimilation of voicing after a nasal in external sandhi. Yet Vasiliki reacted to invented masculine

'foreign' names such as Top and Kop (containing final stops, not permitted in Greek) with (Accusative) to tóp and to kóp instead of the ton dóp and ton góp expected.

Such forms present us with an insight and a problem. The insight is that children probably recognize quite early what constitutes a native shape and what a foreign one: but why should they react to the foreign words by using what would seem to be the more far-reaching rules of a (developmentally) earlier stage?[27]

One answer might be that the question is in fact ill-formed: if the word is recognized as foreign,[28] then perhaps its integrity must be preserved--an end most simply achieved by the disposal of the segment (the nasal) which would modify it.

Footnotes

1. This paper is slightly modified from that read at the December 1971 meeting of the Linguistic Society of America under the title 'Language acquisition in Greece: some preliminary findings." The study on which this paper is based was partly supported by a Summer Grant-in-Aid awarded by the College of Humanities, the Ohio State University. We warmly thank the authorities and staff of the Greek Red Cross and PIKPA for access to children in the Asklipiion and Christodulakeion Day Care Centers in Athens, Greece.

2. The poem concerns the perhaps not everyday spectable, for an Athenian child at least, of the encounter of a hedgehog with a vicious snake.

3. Cf. Pike (1949) for one explanation--an explanation which perhaps is less plausible here, considering the 'advanced' age of Elena.

4. The context makes this quite clear: Elena had hurt her own left leg.

5. Cf. the (controversial) case of disruption which concerns the conservation of quantity, in Mehler and Bever (1967), and the reply in Piaget (1968).

6. The examples in (4) are (the only occurring) exceptions.

7. As we expect, the dental nasal is also present, as in

neráki	→ neláki	(water)
ikónes	→ itónch	(pictures)

8. The establishment of 'first stop' cannot, of course, be disassociated from the methodological problem of identifying the 'first word'.

9. C. P. (27 months) has here a prosthetic vowel, as also seen in alávi for láði 'oil'. In otómo for stóma 'mouth', the bilabial nasal obviously also provokes rounding harmony.

10. Cf. ayóri 'boy'; and makaRán, for 'makaróni', where final i has been deleted.

11. As it did in certain dialects (e.g., Elean) of classical Greek, cf. Lejeune (1955).

12. The output, kutíəli, probably provides a genuine example of anticipatory vowel harmony in which the stressed syllabic is dominated by an unstressed one (Cf. section 4.1); but in fact this is the optimal environment, in which the unstressed vowel on each side provokes harmony of vowel height. The adult form tsekúri alternates, for many speakers, with tsikúri: but the form here was a response to an adult tsekúri, as the tape confirms.

13. This might simply be [t] from [s] after cluster simplification (cf. siopí → topí); but compare also sófi 'Sophia' → gópi ~ góki: sómba 'stove' → gómba ~ yómba ~ dómba.

14. The final prompted form is a shouted (exasperated) response, syllable by syllable.

15. The spontaneous form is unrelated to the proper adult form; it is probably related to adult kokoríko 'cockerel'.

16. That there is, on the other hand, a similarity between this prompted recall and the list-recall used for adults is startlingly brought out by an occasional case of interference by 'recency': unable to construct a relationship between adult sto mayazí 'at the shop' and the child's to magilávi, we noted the previous question was tí pulái sto mayazí 'What does he sell at the shop?'; the words tí pulái seem to have been blended with the child's form mayayí 'shop'.

17. 'Irregular' here only means that a given set of rules does not always operate on a particular form; the context sensitivity of rules, already referred to, probably fluctuates at the early stage of acquisition.

18. Thus, 'refrigerator' (section 4.3, example 1) reverted quite firmly to the earliest (spontaneous) form, sibío.

19. The converse, that children who show little or no improvement under prompting remain behind their improveable peers, seems disconfirmed from the report of Templin (1966): lack of such improvement probably relates more to temporary reticence than to abnormally delayed language development.

20. Sandhi also applies with pronominal enclitics (see fn. 21), with the particles ðen and min, with the numerals énan, mían, and with adverbials like an, san, prin, ótan, with greater or lesser degrees of freedom. For the long-standing controversy on the analysis of Modern Greek stops, see Householder (1964). For the analysis of the adult language assumed here, see especially Hamp (1961) and Newton (1961).

21. E.g., for the pronominal enclitics, loss of the nasal before continuant is optional for Feminine, but excluded for Masculine (which would otherwise merge with Neuter).

22. Tense can, of course, only be considered a cover-term at this time.

23. 'Nasal disposal' is intendedly a neutral term, since it is a moot point whether a rule called 'nasal loss' is really justified here.

The environment VNC seems to provoke vowel nasalization readily: best, when C is a voiceless continuant; slightly less

well, when C is a voiceless stop. The reason is that, since the velum is necessarily raised for an obstruent (ballistically for a stop, but under control for a continuant) it is lowered prematurely for the preceding nasal segment.

But if the velum-lowering is sufficiently early, the stop component may well be inhibited altogether; the time allotted to the nasal will be added to the preceding vowel, since that time is required in any case for the velum to rise again for the following consonant. Alternatively, however, the velum may be late in lowering: in this case, nasality itself may be lost, and the nasal stop may then assimilate to the following consonant both for manner and place of articulation.

For those languages that thus 'lose' nasals, it may prove to be the case that a) if the language possesses contrastive vowel length, then this will encourage disposal of the nasal 'to the left'--i.e. vowel-assimilation, while b) if a language tolerates geminates, this will encourage nasal disposal 'to the right', i.e. consonant assimilation.

Seen in this light, classical Greek (which had both conditions) was free to dispose of nasals in such environments in either manner.

Modern dialects that tolerate geminates are the 'peripheral' dialects; for example, those of the Eastern Aegean: of these dialects, Cypriot, Chios, and Carpathos dispose of the relevant nasal 'to the right' before continuants, while Carpathos does the same even before stops (Cf. Thumb, 1964). But the Standard language shows neither contrastive vowel length nor geminates; we thus expect that neither of the above results can appear as an output--a long vowel will always shorten, and a geminate will always simplify, with the result that a nasal will appear to be simply 'lost'. However, the underlying processes may well appear in child language, where we would predict that, while a geminate might not be tolerated for the early stages referred to, overlong vowels are common and would perhaps not be reshortened as in the adult language.

The child data mostly shows the expected adult result, i.e. apparent 'loss' of the nasal; but there are one or two cases also of lengthened preceding vowel, as predicted. Also as predicted, no cases of gemination appear--though it would be interesting to observe at what age Cypriot children (e.g.) acquire their geminate consonants.

24. The nasal is still optionally disposed of in the adult language.

25. Drachman (1971) argued that the likeliest strategy at such a point of forced change might be "Do what you must--but only where you must." It is that pessimistic suggestion which is perhaps challenged by the present case.

26. If it were true (pace Vennemann, 1971) that a segment not produced by a rule for contextual allophony is to be represented "as it is", then the kind of segment reinterpretation by generalization discussed here could not occur.

27. This is also a possible adult treatment of contemporary 'foreign' words--although there are names in Greek, mostly of

biblical origin, which are treated by adults as 'native' even though they contain 'forbidden' final consonants, e.g. yavríl 'Gabriel', ðavíð 'David', etc.

28. Both the occurrence of a non-permitted final consonant and the (English-based) aspiration of the initial stop are relevant.

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Phonology and the Basis of Articulation[1]

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Abstract

There is a tradition in Europe, going back at least as far as Wallis in the seventeenth century and continued in the work of Sweet, Viëtor, Jespersen, and their contemporaries over the end of the nineteenth century, concerning the characterization of what it is to speak like a German, a Frenchman, or an Englishman. It is a tradition[2] still in fashion with language teachers--though to some extent only as a matter of lip-service, since with honorable exceptions (e.g. Malmberg, Delattre) the Basis of Articulation has been largely ignored by theoretical linguists over the past decades. Nevertheless, it is proposed here that the insight central to the notion Basis of Articulation in fact illuminates some important issues in present-day phonological theory, and that the notion itself--although in somewhat modified form--must be revived.

First, I shall relate the notion Basis of Articulation to the wider question of 'preparatory setting' as it bears on the understanding of skilled motor behavior in general: it will become clear that we must consider not only preparatory but also ongoing tendencies, with 'local' as well as universal elements.

Second, I shall briefly sketch what modern experimental methods suggest concerning the universal and language-particular elements of the Basis, and give examples from several languages.

Third, I shall try to show how these findings mesh in a natural way with, and thus enrich present-day phonological theory. In introducing the notion 'causal unity' into the consideration of phonetic processes, I shall argue that the processes thus provoked or constrained constitute a natural sub-component of the phonology of language, one which ignores the line commonly drawn between competency and performance.

I shall, finally, suggest how the child 'acquires' the Basis required by his language, and thereby derive a possible explanation for both the gross similarities and the individual variations of the Basis of Articulation for speakers of the same dialect.

1. The Basis of Articulation.

1.1. The control of skilled human motor behavior may be likened to the control of a delicate multi-purpose machine by some kind of servo-mechanism, that is, by a device that returns information to the command system concerning the current state of the moving members.

Thus the primary command system consists not merely of a device transmitting pre-arranged commands coded for a given activity and in a given sequence, but also of a monitor or feed-back device. But there is a third device required for all but the crudest control systems, that is, some way of setting the ranges over which the members may respond and also the threshold of sensitivity of the members. It is with this third, bias or feedforward device that the machine is in fact primed,[3] both for the onset of performance and for its continuance; and it is obvious that such priming will necessarily be specific for each code of activity-commands.

1.2. The commands to the speech tract are neural instructions for muscle-movements according to the speech code, and the tract feed-back consists in acoustic and proprioceptive information. What of the feedforward?

The speech tract consists of members such as the larynx, pharynx, tongue, velum, etc., all of which also possess vegetative functions for the speaker. The adoption of a speech mode thus itself dictates certain universal aspects of priming, of which I shall name but two. First, certain otherwise autonomic functions of the tract are brought under speech-program control[4]--breathing is the best example. Under spinal cord control, rest-breathing has a regular cycle of approximately equal inspiration and expiration phases, inspiration being controlled through certain muscles of the chest and abdomen, while expiration is provoked as a reflex, through the elastic recoil of the lungs themselves. In speech, this cycle is replaced by one in which inspiration (by the same muscles) is quite rapid, but expiration is closely controlled so that (as Ladefoged 1962 has shown) a constant pressure-difference is maintained across the vocal cords for some seconds despite the fall in lung pressure. Within quite wide limits, then, we are free when speaking to plan sentences much longer than the time for non-speech expiration, without needing to pause for breath.

Second, certain sets of muscles normally working together must be disassociated. The velum-raising muscles normally work together with the muscles of the tongue and the pharynx and larynx, all of which must contract in a certain pattern (Negus 1949) if swallowing is to be effective. In speech, however, the velum must on the one hand be controlled quite independently; on the other hand, the larynx must be raised, but <u>not</u> carried forward as in swallowing.

Thus the feedforward device must initiate recoordinations for whole systems of muscles as part of the decision to operate in the speech mode. Experimental evidence suggests that such mode-specific re-coordinations also dictate the stance of the larynx, the pharynx, and even the internal musculature of the tongue.

1.3. There is now a certain amount of evidence, too [albeit mainly gathered for English speakers, and then only for single speakers as a rule], to show that the priming activity postulated for skilled motor activity can actually be detected measurably before the onset of speech production. For both English and

Japanese, for instance, the vocal cords are clearly in a partly adducted attitude fully fifty milli-seconds before they are set into vibration for a vowel; for English, the ultrasound recordings of Kelsey et al. (1968) show the pharynx relaxed measurably before voice onset; and other recordings show the raising of the larynx, the raising and drawing forward of the tongue (Perkell 1965), and the raising of the velum (Björk 1961, Fritzel 1963), etc. Most instructive is the case of the velum, which rises at speech onset; notice that this rise may be seen (Kozhevnikov and Chistovich 1965), briefly but clearly, even if the first segment of the coming utterance is to be a nasal consonant--i.e., a consonant actually requiring the velum to be lowered.

So clear is this distinction between the vegetative and speech functions of the vocal tract that their accidental intersection can cause serious problems. Consider the health hazards of speaking while eating--as already noted, for speech the larynx is not carried forward as required for swallowing, with the result that food may cascade over the tongue and into the lungs via the partly open cords. Or consider the span of a single breath group when contradicted either by the requirement of a closed glottis, as when trying to hold a conversation while carrying a very heavy object, or in extreme cases such as speaking while suffering severe pain or even while laughing.

Finally, consider the survival or re-emergence of elements of the autonomous program in speech-defects such as lisping (perhaps attributable to the dominance of the sucking reflex), or in drooling and similar regressions noted in the speech of child psychotics or retardates (Luchsinger & Arnold 1965).

1.4. Less unambiguous at first sight, but I think no less surely to be inferred from the records, is the ongoing activity of the Basis. If we look on the ongoing Basis as a matter of tonus-adjustment, then the records become quite clear in its favor. For the members of the tract do not fall back to their rest positions during the utterance, or even (sometimes) across utterances. Thus, the velum lowers for a nasal consonant, but not as far as the rest position; and the same is true of the height of the larynx, the length of the vocal cords, even the width of the pharynx. In general, experimental work suggests that, once set, these subsystems probably retain their tonus, at least for the length of a breath-group.[5]

2. Language specific elements of the Basis.

2.1. Some elements of the Basis of Articulation are likely to be substantively universal; thus, it is hard to imagine a language utilizing some special type of breath-group, and so requiring a language-specific breathing rhythm. On the other hand, it is possible for some very few languages (or even one) to employ a certain unusual mechanism or timing, etc., not employed by the majority of the world's languages; such a case is the complex mechanism producing clicks in a small number of African languages.

But for the great majority of languages, the mechanisms employed will prove to be largely in common, though with detailed differences of placement, timing, etc. The most notorious of these common mechanisms and their stances are those perfectly well known from the classical work on the Basis of Articulation as described for English, French, and German by such scholars as Sweet (1892), Sievers (1901), Jespersen (1913), and Viëtor (1884); they concern mainly the attitudes of the tongue and lips, mutual influences of consonants and vowels, and factors such as force of articulation.

It is I think no accident that, although I have extended the notion of the Basis to embrace a wider range of phenomena, the known elements continue to play a central role in the account, for these elements indeed prove to be among those responsible for the more global effects of the Basis, that is, among those which seem to implicate whole sets of phonetic processes.

Let me illustrate the notion 'global effect' by a brief survey of some of the elements in the Basis of Articulation for three languages--French, Swedish, and Lappish.

2.2. From the work of Delattre (1953) we may derive three principles (Delattre calls them 'modes') that account for a diversity of phonetic facts about French: in particular, the modes control not only the exact qualities of consonants and vowels but also their cohestion--that is, the shapes of syllables. I take first the mode 'tendu', a term referring to the level tension on the muscles of the tract during phonation. Its results are diverse. No glides of intonation appear, nor is there any centralization of vowels (shwa is thus the only vowel to suffer reduction and loss, even in fast speech). There are no falling diphthongs. No intensity variations appear, moreover, and stress is realized as duration.

Second, consider the mode 'anterieure'. This mode almost constitutes an acoustical output constraint, for in its most generalized form its definition is simply 'frontal resonance'--a condition fairly guaranteed for French when we recall that the consonants consistently coarticulate with vowels, and that the vowels are in fact preponderantly either front, or front and rounded, or simply rounded: only /a/ and perhaps shwa are neither front nor rounded.

The twin elements of the mode 'anterieure', then, are a fronted tongue dorsum (plus concomitantly lowered tongue tip) and complete freedom of the lips to coarticulate with a following rounded segment. The general fronting of the tongue allows the effective palatalization of a lateral, while the lowered tongue tip encourages its vocalization (confirmed by l-loss in fast speech[6]); the lowered tongue tip also simultaneously prevents the palatalization of dental stops, even in the most casual or fast speech--compare English 'he's yours': French 'les yeux'--even as it provokes the dorsal pronunciation of French /r/. Consider too the apparent absurdity of the fine phonetic definition of dental /t/--viz., that it is a blade stop before front vowels, but a tongue-tip stop before back vowels--facts that automatically follow from the fronted, tip-down attitude of the tongue.

Delattre's third mode pertains to syllabics--it is his mode croissant. The articulation of the French vowel is characteristically even in onset, steady (or even rising) in intensity at its target, and swift in its offset--all of which stand in contrast, incidentally, to the corresponding conditions for English. The consequences of this 'mode' are first, that an intervocalic consonant is strongly dissociated from the preceding vowel, and conversely strongly tends to make a syllable with its following vowel--this is the source, then, of the open syllable. But the consonant in fact coarticulates so strongly with its following vowel that it not only anticipates its coloring (as with consonants befor labalized vowels) but also its voicing--so that while voiceless stops are unaspirated, voiced ones are voiced simultaneously with the closure and are thus almost prenasalized. Further, while the non-cohesion of a sequence V + C is exemplified in the full release of final consonants (again, compare the English), Delattre's cohesive CV is once more seen in fast speech, when a sequence of nasalized vowel plus voiced stop often becomes $\tilde{V}$ + N (i.e., nasalized vowel plus nasal). If, as is likely, the early voicing of a stop is achieved by continuation of the velic leakage in such an environment, then it is also likely that in fast speech the velum simply does not have time to retract fully from this lowered stance adopted for the preceding nasal vowel. We thus find [pãnã] 'pendant', [avãnparle] 'avant de parler' (Jones 1972).

2.3. For another aspect of the Basis, that of the relative <u>timing</u> of mechanisms, I turn now to accent-systems in Scandinavian. In most Scandinavian dialects a stressed word may bear one of two types of accent; it may be either Acute (Accent I) or Grave (Accent II), these accents usually reflecting the phonological structure of the word, including the relations of its constituent morphemes.[8] Öhman (1967a) was the first to interpret these accents in terms of a quantative model. Briefly, he supposed the occurrence of a sentence-level intonation pulse resulting in a rising pitch (positive pulse), in conjunction with a word-level glottal signal resulting in a falling pitch (negative pulse).

Öhman proposed, first, that the same two signals are in fact responsible for both accents, depending on their relative timing: for Northern Swedish, for instance, sentence pulse with early word pulse gives acute, and the reverse gives grave. But he then extended the same model to account, in terms of the same relative timing between the two pulses, for the intonation patterns corresponding to the two accents over a very large number of Scandinavian dialects, even including the apparent pitch reversal between the accent pattern for Southern (Malmö) and Northern (Stockholm) types of Swedish.

Such an explanation, so simple in its mechanism, yet so profound in its predictive power, is likely to prove correct in principle despite the fact that the EMG tests in Öhman (1967b) did not quite confirm the predicted laryngeal activity at the muscles

he in fact chose to investigate. And more generally, the notion of the relative timing of the component articulatory gestures for a given segment is a most powerful explanatory tool; though space limitations do not allow details, this could easily be illustrated by a consideration of the different kinds of nasals resulting if we vary the time overlap between voicing, oral closure, and velum lowering, e.g., as between languages like Twana (Drachman 1969b), and Khmu? (Smalley 1961).

2.4. A third language, Lappish, may well prove to exhibit elements already discussed, but in a fresh combination. A principle of syllable shaping proposed for Lappish in Houlihan and Webb (1972) seems to incorporate both notions of syllable structure suggested in the accounts above: viz., that for the French mode croissant[9] and that for the Danish acute accent. If we define Lappish accented syllables as both Croissant and as terminating with a glottal-lowering pulse, then as before a diverse set of processes is apparently determined. Thus, (a) syllable-cohesion prevents a following consonant from geminating back across the syllable-boundary (as occurs for unaccented syllables); (b) a non-homorganic cluster at the syllable boundary will be broken up by an epenthetic vowel; (c) on the other hand, a voiced geminate at the syllable boundary will actually be lengthened, as a consequence of the expansion of the supraglottal cavity resulting from glottal lowering. Finally, (d) the same croissant structure will transform a falling to a rising diphthong in the accented syllable.[10]

2.5. The examples given suggest that the Basis may be looked upon as a kind of unifying principle. Two kinds of unity have been proposed for phonological processes, viz., formal unity and functional unity. Processes (i.e., the rules which formalize them) may be formally united under certain fairly imprecisely defined conditions of symmetry and parallelism in their content or their domain. thus, to take the simplest kind of example, if English vowels are to be tensed in two environments--before vowels, and in final position if non-low--then we might collapse the two processes (Chomsky and Halle 1968--hereafter, SPE) as formally or structurally unified.[11] Alternatively, if various quite different-looking processes such as vowel-insertion and cluster-simplification conspire in their effects, viz., to disallow tri-consonantal clusters in utterances in a language such as Yawelmani, then we might hold (with Kisseberth 1970) that these processes show functional[12] unity.

Analogously, I want to propose that if a small number of mechanisms or attitudes in the tract control a diversity of phonetic processes, so that the activation of one set is made most plausible while that of some other set is rendered most unlikely, then the processes concerned exhibit a causal unity. Thus the Basis of Articulation constitutes a causal principle with reference to the processes which it provokes or blocks for a given language.

But here a problem arises. It is of course possible to define the sets of (respectively) provoked and blocked processes, for a given Basis-definition; but a generative phonology, while its structure is devised specifically to exhibit the positive processes a form is to be submitted to, has no explanatory power with respect to the positive blocking of processes[13] which we also find to be a characteristic of the Basis. How, for instance, could we formalize the notion that the tongue attitude for French automatically precludes the palatalization of dental stops? But is there, if the present treatment of the Basis is reasonable, really any more reason to specify even the provoked processes?

Might we not, that is, allow all these processes dominated by the Basis (provoked and blocked alike) to be 'understood', given the Basis and a suitably rich metaphonetics. What makes this extreme proposal less than persuasive, however, is the simple fact of adaptation; persons with radically different tract lengths and proportions still use the same allophones, and a person with a growth in his mouth quickly adapts to it--in the opposite extreme case, a person losing his tongue through cancer may still produce very acceptable vowels and consonants (Drachman 1969a). An absolute specification of the Basis of Articulation may thus prove elusive even in principle. However, if we consider the Basis itself to constitute a global adaptation to the processes heard to operate in the language concerned, then for speakers of that language there will be 'normal' Basis elements insofar as there are correspondingly 'normal' speech tracts. We should certainly wish to maintain that, for a given tract, and the Basis adapting it to a particular language, the provoked and blocked processes which this Basis dominates are determined.

3. The Basis in generative phonology

3.1. There ought, of course, to be no question of the importance of the notion Basis of Articulation as a unifying principle for pedagogy, and the literature in fact contains injunctions to whole-tract adjustment clearly implying the real-time physiological nature of the Basis (cf. Honikman 1964, Delattre 1951).

Hardly appreciated or even well known, on the other hand, is the possible application of an understanding of the speech-ready setting, for speech-therapy. Yet it has for some time been clear, from the work of Krmpotić (1959), that certain pathologies of phonation may well turn on faulty ordering in the setting up of the internal and external larynx musculature before the act of speech.[14]

3.2. Turning to phonological theory, it is curious how the Basis of Articulation has been almost overlooked in the past decade; notable exceptions being Malmberg, Heffner[15] and Delattre. Within the camps of generative phonology, the reason for this neglect is not hard to divine. Theoretical phonologists have all-too-readily

assumed (vide SPE) that only the grammatically determined aspects of the signal are relevant to the phonological description. The result is that the Basis of Articulation has been relegated quite explicitly to a limbo of Performance also containing factors such as voice-quality, pitch, rate of utterance, transitions, etc.[16]

But in the discussion of the interpretation of Distinctive Features, SPE in fact makes most crucial use of the notions 'spontaneous voice' and 'neutral vowel', notions which fall entirely within the domain of the Basis of Articulation.

First, the notion 'spontaneous voice' is defined in completely physiological terms; if the vocal cords are first adducted to a certain setting, then they will automatically vibrate when 'normal' sub-glottal pressure obtains, provided free egress is given to the supra-glottal airstream. Vowels, semi-vowels, nasals and liquids are thus guaranteed their special status as Resonants, i.e., as segments for which spontaneous voice obtains; and conversely, it follows that voicing in obstruents requires some special adjustment, perhaps by the creation of a larger average glottal opening during the vibration-cycle.

Second, it is fundamental to the SPE definition of the vowels that there be a so-called 'neutral'[17] vowel identified with the English mid-front vowel /e/. But the very notion 'neutral' vowel rests on the use of the most fundamental element in the classical Basis of Articulation--the already-discussed attitude of the tongue (Sievers (1901) Lagerung der Zunge) as its speech-ready position. Thus two fundamental principles utilized in the classification of segments and the definition of Features rest squarely on what I have treated simply as elements of the Basis of Articulation.

Now Ciba and Kajiyama (1958) in fact originally proposed that, since a mid-front vowel /e/ corresponds to a tract whose cross-section is maximally homogeneous, the acoustic qualities of the other vowels could be predicted in terms of systematic distortions in just such a tract. Thus defined, the (acoustically) 'neutral' vowel ought to be a universal of speech-production, and the account in SPE certainly seems to imply just that.

It remains for further experimentation to confirm whether the various challenges to such a contention are justified: I mention only two. Delack (1970) has claimed that, within the present framework, one must, counter-intuitively, characterize the /e/ and /o/ of German as [+High] since they are phonetically higher than the English mid-vowel /e/ in 'bed'. To avoid this, while not rejecting the fundamental insight contained in the notion 'neutral' vowel, he proposes to redefine 'neutral' in terms of the /e/ vowel in the language concerned. In effect, Delack is thus perhaps not unreasonably insisting that the neutral tongue position is language-specific.[18] More extremely, on the other hand, Ladefoged et al. (1972) baldly state that their data 'give no support to the notion that the tongue should be in the neutral position in 'bed'.

But the relegation of the Basis to the interpretative component in this way,[19] though consistent with the claim that rates of utterance are of interest only in a performance model, is in fact

quite inconsistent with the facts of 'rates of speech'. First, it seems to be the case that (contra SPE) no useful dividing line may be drawn at the grammatically defined phonological output: in fact, between very careful speech and extremely fast speech stretches a seamless web of processes, extending from dental Palatalization (as in [gó͡ʧə], 'got you', well within the limits of SPE) to dental Flapping, loss of Flap and glottal insertion (as in [bɛ́ʔi], 'Betty' lying well beyond those limits), all processes of seemingly equal status and structure.

Second, the fact that fast speech phenomena are predictably generalizations of slow speech ones (better, slow speech phenomena are limitations on fast speech processes) shows that the phonetic output over the whole scale of speeds (or degrees of casualness) is in fact locked to the one and the same Basis of Articulation--and is in fact provoked by it. It follows that the Basis is not a part of the interpretative component in the sense of SPE, but that it stands in command of processes whose output is (as claimed above) not interpretable so much as predictable.

3.3. The facts concerning the Basis of Articulation must, then, be somehow stated before the processes which it dominates.[20] But there is an important sense in which all the rules in a phonology presuppose for their operation a part of some Basis of Articulation. Is it thus the case that the total set of statements of the Basis is superordinate to the whole phonology, and must be given at the outset?

The facts make such a conclusion highly implausible. First, rules for (e.g.) the English Vowel Shift (giving alternations such as divine - divinity, profane - profanity) or for English Spirantization (giving corrode - corrosion, evade - evasion) in fact formalize historical debris in the language, and the present Basis can hardly have anything to do with their phonetic plausibility as rules--that is, they are 'dead' or simply 'learned' rules. If the Basis is invoked to explicate these, then theoretically we have opened Pandora's box, and any series of historical survivals would require a corresponding series of Bases to explicate them.[21]

Second, and conversely, it is clear that the processes found in children's secret languages, or those known as slips of the tongue[22] never 'undo' rules like Vowel Shift in English or Umlaut in German, while they always undo Palatalization in English or unvoicing of final stops in German--which again corresponds to the fact that it is the latter kind of rules (the 'live' ones) that are as it were guaranteed by the Basis, but not the former.

3.4. Now while the Basis applies only to the 'live' processes in the language, it must yet be clarified that the Basis does not in fact of itself guarantee the operation of even these processes; that is, even these processes do not behave as passive reflexes, to be triggered whenever the relevant stimuli (i.e. segments) are present. Let me give a simple example of what this means.

In Japanese, high vowels are unvoiced in normal speech when they fall between spirants. This fact might well be associated with the very high air-flow requirement for spirants, the cords tending to remain more open during the intervening vowel also, with resultant passive unvoicing of the vowel. But research has clearly shown two curious facts: first, it is not the case that each of a series of vowels between spirants will unvoice (Han 1962); and second, that innervation of the vocalis muscle is always and only present when voicing occurs, and absent when voicing does not occur (Hirose et al., 1970). Thus though a predisposition is present, a choice must be made, and a command given.

Such evidence, supplemented by the mass of exceptions (whether for grammatical or lexical reasons) to so-called fast speech rules (e.g. Zwicky 1970, 1972), as well as by the fact that such rules are often operative in quite slow speech, suggests the following interpretation.

The live processes in a given language are supported by corresponding elements in its Basis of Articulation. But the processes whose outputs are acceptable to a given speech community (e.g. its casual speech processes) are still not physiologically but rather culturally-bound phenomena. I believe it is unreasonable to demand of the common code that it contain elements not under the voluntary control of its users,[24] and would thus claim that acceptable processes are always within the limitations of the (Basis-orientated) tract.

I do not think this somewhat extreme view stands to be straightforwardly contradicted, even from the most obvious sources--e.g., from the data for co-articulation: on the contrary, Öhman's (1966) coarticulation data indicate clearly that even such an apparently automatic process may be voluntarily constrained, as the Russian data shows. On the other hand, the status of drunken, drugged, or epileptic (ictal) speech is quite unclear vis-a-vis the principle of voluntariness I have subscribed to.[24]

3.5. Which end of the scale of casualness (or speed) is the Basis set for, the most careful or the most casual speech acceptable? I should like to claim that the Basis is set up to collaborate with the most casual speech permitted in a particular dialect--the most casual style being that permitting the richest and most far-reaching set of processes to apply.[25]

For different degrees of casualness in a given dialect it is likely that what is adjusted is not separate individual details of the feedforward system, but simply the overall threshold setting for the system as a whole. It is important to note that such a threshold adjustment does not result simply in the cutting off (or addition) of the 'lowest level' rules, but rather in a shift in the threshold of each individual rule--where threshold levels correspond to places along hierarchies, rule for rule. Thus, for instance, if a dental stop is in the most casual speech palatalized before both i and y, then a more careful style might still allow palatalization before y alone, but never before i alone, since y is the most palatalizing environment.

On the other hand, for other dialects the feedforward will require differential adjustments of detail (e.g. the re-timing of the word-pulse in relation to the sentence pulse, for Scandinavian accents) while the decision to speak a different language will for the true bilingual perhaps require a wholesale and differential re-adjustment of <u>all</u> the elements of the Basis.[26]

4. Acquisition of the Basis

4.1. It is reasonable to assume that it is a natural property of the child's muscle-control system to incorporate not only feed-back but also feed-forward devices, that is, to utilize overall preparatory and ongoing tonus adjustments that are specific to a code--in the present case, language. I shall also assume that the child has stored correct mental representations of the forms of his language, and concern myself here only with the question, how does he reproduce specific segments?

The child's problem is to map acoustical representations into appropriate physiological mechanisms (cf. Drachman 1971), and so to adjust the preparatory settings and ongoing tonuses for these mechanisms as to guarantee maximal ease of production over the while range of styles, from most careful to most casual, sanctioned for the dialect of his speech community.

4.2. As was pointed out earlier, the change-over in the breathing system is probably completely innate; but notice that even here there may be developmental disruptions; for the attempt to utter long phrases requires practice, and it is not uncommon for a child to speak alternately on outgoing and ingoing breath at some stage of development (Drachman and Drachman 1972).

Whole-spectrum shifts are to be seen on spectrograms of infant vocalizations (Truby, et. al. 1965): this suggests that at the stage when the infant tongue is still rigidly positioned during vocalization, the larynx may already be raised or lowered. Thus it seems that, as for the velum, so the muscles regulating larynx height can early be controlled independently of those with which they must work synergistically in swallowing.

On the other hand, so far as the speech-ready attitude of the vocal cords themselves is concerned,[27] a maturation series is to be postulated. Setting aside the stages of infant screaming, crying and cooing, which contain predominantly vowel-like sounds, we take first babbling; and here, as onsets to (only) open syllables, all obstruents seem to be voiced by anticipatory assimilation. However, at the so-called onset of speech, with its imitation of adult shapes (whether or not with the accepted adult meanings), a developmental disruption seems to occur in some cases (e.g., Leopold 1947); all consonants are suddenly for some time voiceless (even whispered), and vowels seem to assimilate to consonants, becoming in turn voiceless. Shortly thereafter, vowels re-voice, and prevocalic consonants again assimilate to them for voicing--

whether in open or in closed syllables. It is only later still that the child achieves control of voicing in obstruents, so that pre-vocalic obstruents may at length be voiceless, and final obstruents may be voiced (cf. also Velten 1943).

As was mentioned above, the infant tongue is rigidly positioned at a fronted shwa-like configuration in screaming, a characteristic the infant has in common with the ape (Lieberman 1968). But the infant soon commands the tongue-moving musculature, both intrinsic and extrinsic, and later infant pre-speech vocalizations seem to employ a tongue which is cupped, reminiscent of the internal-rounding configuration described for Tillamook (Thompson and Thompson 1966). It is not clear at what stage the characteristic convex or concave tongue shape is first employed, nor of course at what age a 'neutral' attitude is first taken up preparatory to the utterance.

More generally, it may be said that the child quickly discovers through acoustic and proprioceptive feedback--the oral chamber being particularly rich in sensory detectors--the acoustical output capabilities and limitations of all possible combinations of mechanisms, and this perhaps even as early as the stage when he is capable of producing "all conceivable sounds", (Gregoire 1937) in babbling. But in fact he may be assumed to have also discovered even more--he may also have discovered cases where alternative combinations of mechanisms produce approximately the same acoustical outputs.[28]

4.3. What, then, guides the selection of the most suitable mechanisms, in the face of such possible alternatives? And what guides the decisions concerning appropriate settings and tonuses? It was pointed out earlier that the facts of adptation in pathological cases proved that "the processes select the Basis of Articulation." And indeed, this seems an effective strategy for the child's choice of mechanisms; he remarks especially those environments in which it matters which mechanism he chooses. Thus, for example, the Greek child hears the name Tasso as [táso], but its Accusative form /ton táso/ as [ton dáso]: he must thus assign the Feature Lax to word-initial voiceless stops, for these are the tokens of voiceless stops which are permitted after a nasal in external sandhi (as in the example). Now in the first place, this is a decision applying to voiceless stops only in this particular environment; but the child may very well soon thereafter apply the re-interpretation to heard sequences of Nasal plus voiced stop within words as well. Drachman and Drachman (1972) suggest that this re-interpretation is in fact carried out quite early by most children learning Greek as a native language. We find occasional child forms such as [yíɣantos][29] for adult [yíɣandos]; the medial sequence [nd] of the model [yíɣandos] has been re-interpreted as /nt/, at a stage when the rule which would convert this to [nd] is still constrained to word-initial position.

4.4. Are there rule-guided environments such that a single unique choice of mechanisms is forced upon the child for a given segment-

type? If, as Öhman (1966) and Perkell (1969) have suggested, the natural substrate of the speech-production process is the ongoing vowel gesture--and the prevalence of vowel-harmony in child language tends to confirm such a hypothesis--then it might be claimed that a child acquiring a language which exploits this very principle (i.e. a 'vowel-harmony' language) is under exceptionally strong rule-dominance to find a consistent mechanism. In such a case, the most appropriate mechanism should be stable not only for a given individual but across whole (dialect) communities at least.

For simplicity, let us confine our attention to harmony languages like Igbo, languages in which the vowels of words must all be chosen consistently from vowel pairs related by tongue height.[30] Now the work of Lindblom and Sundberg (1971) and others shows that absolute tongue height may in fact be achieved by differential combinations of three factors, viz., jaw opening, tongue raising and tongue root advance. Do the speakers of such languages in fact consistently use a single dominant tongue-height-producing mechanism?

Recent work by Lindau et al. (1972) provides a qualified 'yes' to this question--qualified because data for only a single speaker for each vowel-harmony language was examined, but 'yes' because each speaker did in fact seem to consistently use a single mechanism to distinguish the vowel sets concerned. But the matter is a little more complex: while for (West African) Asante Twi and (Western Nilotic) Dhu Luo the mechanisms chosen seems to be tongue root advancing, the speaker of (Eastern Nilotic) Ateso used only tongue raising.

Matters for non-vowel-harmony languages like English and German, on the other hand, are frankly puzzling. Since the Tense and Lax vowels for both English and German are strongly distinguished by length, one might have expected the height distinctions to be achieved in quite personal mixtures of the three possible control factors. For three of the (Lindau et al.) speakers of English, this proved a true prediction: but three other English speakers and also the one speaker of German in fact showed consistent use of tongue root advancing.

Our hypothesis is only weakly confirmed: but one would at least wish still to predict that no speaker of Asante Twi uses a varying mixture of vowel-height-inducing mechanisms. Conversely, assuming there are no 'live' processes in English or German connecting forms for which Tense and Lax Vowels alternate,[31] we would expect individual variation in the Tense-Lax mechanism no less for speakers of those languages than for speakers of (say) Nez Perce, for whom vowel-harmony occurs but is no longer at all a matter of surface phonetic symmetry.

4.5. But this is not the only source of the child's decision-forcing data. Recall that the Basis of Articulation is also responsible for the fact that different styles of a given dialect are still recognizably part of that dialect, that is, that <u>thresholds</u> are adjusted globally within the dominance of the

Basis: it follows that the hearing of that very same range of styles from syllabifications to mumbled (but perhaps not blurted) speech, and the induction of the processes linking them, provides the data for decisions on the appropriate settings and tonuses. Insofar as heard slips of the tongue, hesitations, Pig Latin usage, etc., are similarly contributory data to decisions on the Basis of Articulation, it is clear that the full range of Performance factors, the full spectrum of speech phenomena is essential to the acquisition process.[32] Conversely (to conclude with a paradox), suppose by the fiat of the "Academy for the simplification of the Mother tongue" that a whole generation of children were always to be subjected to a single and unique shape for each morpheme of their native language, it is unlikely that they would come to a common set of decisions on the mechanisms of production--and thus the stage would immediately be set for who knows that innovations within that single unfortunate generation!

Footnotes

1. This paper was read to the Linguistic Society of Vienna, and to the Auditorium Academicum, Salzburg, June 1972. To appear in Die Sprache.

2. In such a tradition one characterizes (e.g.) British English as 'clipped' and precise; American English as nasalized, drawled and careless; male German speech as pharyngeal; French and German speech as vigorously lip-rounded; and speech in the languages of India and Pakistan as 'slack-jawed'.

3. Cf. Lashley's (1951) seminal paper. Though the present paper is concerned mainly with the phonetic output, in fact the whole language system must be considered as a single priming unit when considering the facts of perception. In this respect, there is reason to believe that the ear is also primed as a receptor.

4. I do not wish to imply that speech is, after all, an 'overlaid' function (Cf. the strictures in Lieberman 1968); but clearly the vegetative and speech programs have distinct statuses.

5. In Japanese, for instance, while the lateral crico-arytenoid muscles alone dictate the larynx-internal <u>preparatory</u> stance, these muscles must apparently work together with the vocalis in controlling ongoing tonus (and thus voicing) <u>during</u> the utterance (Hirose et al., 1970).

6. Cf. careful [finalmã] 'finalement', with casual [finamã], Jones (1972).

7. English [hisĭzyu] 'he sees you'; but French [lezyø] 'the eyes' never gives [lezyø], even in the most casual style.

8. Cf. Swedish:

Tone I		Tone II	
fȧgel	'bird'	fȧglar	'birds'
kall	'cold'	kallare	'colder'
and-en	'the duck'	ande-n	'the spirit'

9. This must for the moment be considered a programmatic analysis, in the absence of experimental evidence that amplitude differences during a syllable are in fact perceptible in normal speech. Cf. the strictures in Lehiste (1972) on this score.

10. The common phenomenon of semi-vocalization of a front vowel before a back vowel (e.g. in Modern Greek, cf. Hadzidakis 1905) is probably to be attributed to the same tendency to croissant syllable structure.

11. But compare the critique in McCawley (1972); and the continuing controversy over the Sanskrit ruki-rule in Zwicky (1970), Vennemann (1972), and O'Bryan (1972).

12. Cf. also Kim's (1970) principle of implosion, for Korean.

13. The standard mechanism for directly blocking a rule applies only to lexical exceptions to that rule, and consists simply in marking such items [minus next rule]. Rule ordering is of course the standard procedure for indirect blocking; but again, this mechanism is only overt in formalizing historical change, synchronic dialect comparison, or of course, language acquisition in the child.

14. It may be that, as with many 'triggered' innate abilities, acquisition of the proper Basis of Articulation is permanently inhibited if it does not occur in early childhood. There are cases of congenital cleft palate, for instance, where despite excellent surgical procedures proper closure of the velum is never acquired. On the other hand, however, consider the complex adjustments successfully made in certain cases of laryngectomy or even glossectomy surveyed in Drachman (1969).

15. Though Heffner (1950) despairs of a method of measurement being devised that would permit the mathematical description of the Basis of Articulation. Cf. section 2.5 above.

16. E.g., in Chomsky-Halle (1968), who in fact quote Marouzeau (1943) as defining the Basis of Articulation as "the system of characteristic articulatory movements of a given language that confer upon it its general phonetic aspect".

17. Cf. the term 'neutral tongue position' in Jakobson, Fant, and Halle (1951). The notion is fundamental in the sense that the mid-front vowel ought then to be the result of the removal of all positive vowel commands--hence the specification [-Back, -High, -Low]. It is not clear how such a reflex of what is perhaps ultimately an acoustically based priming stance in fact corresponds to the classical notion that shwa is the articulatory neutral vowel.

18. In particular, that the tongue-stance for German is higher and more frontal than for English.

19. As also in Lieberman (1970).

20. But surely not as rules: such rules would indeed have a quaint status, each being linked to some discontinuous set of 'lower' rules, insofar as each mechanism provoked such a set.

21. It would be worth exploring whether this is in fact a necessary part of any historical explanation, in conjunction with the fact that 'early' processes in synchronic phonologies often

show integer-like hierarchies. Conversely, the persistence of a given Basis element must somehow relate to Sapir's 'drift'.

22. Cf. the parallel facts for aphasia involving peripheral as against central language systems, as in Whitaker (1971).

23. As noted above (3.3), the Basis survives slips of the tongue, though these are of course not voluntary.

24. Cf. also stage conventions for non-local dialects; secret languages such as one (heard by the author among school children in Los Angeles) in which all vowels are replaced by [i]; speech with clenched teeth, closed or open mouth, etc.--in which part of the Basis is rigidly fixed, without contextual variation.

25. The status claimed here for the notion 'most casual speech' is independently given similar emphasis in Dressler (1972).

26. The semi-bilingual, in turn, may impose the Basis for his primary language upon his secondary language. Some so-called substratum influences in language change may thus depend on the substrate Basis.

27. The sphincter action of the glottis is of course operative from birth, as is evident from the hard 'attack' quality of infant screams.

28. The notion 'same output' is of course very difficult to quantify, going as it does with the acoustical equivalent to 'sloppy identity'. In any case, 'same' does not at all mean 'identical', pace Mermelstein (1967). Unclear in another way is the assumption that we can define a 'normal speech tract' for a given sex and age--an assumption unwarranted as much because of differential rates of development from child to child as because of individual genetic differences (cf. Brosnahan 1961).

29. The age at which such variants appear (8-9 years) makes it interesting to consider how the learning of the spelling system interacts with this reinterpretation.

30. The test case, clearly, must be a language in which vowel harmony shows complete surface (i.e., phonetic) symmetry. Compare the contrary prediction for a language in which vowel harmony is no longer symmetrical on the surface, as e.g., Nez Perce.

31. At issue, at first sight perhaps, is the kind of 'productivity' attributable to a rule of English such as Tri-syllabic Laxing. But notice that, thanks to the Great Vowel Shift and applied vowel-adjustments, no surface pairs directly related by the Feature Tense/Lax survive.

32. This completely justifies certain aspects of the 'degraded sample' supposedly presented to the child; to which reference is often made, e.g., in SPE.

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On the Notion 'Phonological Rule'[1]

Gaberell Drachman

1. Introduction

Phonological analyses are commonly formalized in terms of derivations, any derivation consisting of a sequence of outputs generated by a train of (partially) ordered rules operating on an abstract underlying shape. The metatheory underpinning such an analysis naturally contains the terms 'rule', 'rule-order', and 'derivation' as unanalyzed primes. There are a number of ways in which one might attempt to justify the introduction of such primes into a theory of phonology.

1.1. Formal criteria.

The first criterion is purely formal. If one constructs a system using such primes, they are justified insofar as they make a workable system and are in fact (experientially) interpretable. Even then, it is to be noted, on the assumption that the relations between at least some of the phonetic representations within paradigms or across morphological derivations are not synchronically random (i.e., suppletive), the adoption of rule-derivations involves a covert claim about human information-processing, viz., that related representations are not simply stored separately, but that use is being made of the systematic regularities found to construct an economical overall system of representations and rules.[2]

1.2. Substantive criteria.

The second kind of justification of primes involves appeals to various kinds of reality outside the system itself, i.e., considers the desired interpretation, at the point of choosing the primes (cf. Hempel 1953). Here fall, first, the problem of psychological reality and the problem of real-time models, for which I give brief examples only; and second, the problem of acquisition, to which the remainder of this paper is devoted.

1.2.1. The psychological reality of allophones and inventory-segments may be demonstrated (e.g.) from slips of the tongue (Fromkin, 1971), from naive syllabifications (Sapir, 1925) or even from Pig-Latin-type childrens' secret languages. In turn, attempts have been made to justify quite abstract underlying representations by appeal to the nativization of loan words (Hyman, 1970), while the possibility of demonstrating the reality of 'levels' of phonology

is perhaps illuminated by studies in aphasic speech (e.g., Whitaker, 1971).

1.2.2. The requirement that the language model be one that explicates the real-time processes of speech production or perception is a constraint so far set aside by generative phonologists (as by syntacticians), who have tended to assign to a (usually quite unspecific) model of Performance only such so-called peripheral matters as speed of speech, co-articulation, and the Basis of Articulation (cf. Chomsky and Halle, 1968), together with such (again ill-defined) notions as 'strategies for the use of Competence'.

1.2.3. But it is worth inquiring whether 'possible performance' does not in fact define the content of Competence. In particular, it might be claimed that the neuro-physiological mechanisms available to the child as a beginning language-learner are in fact sufficient to account in a natural way for at least parts of a language sub-system such as phonology, and containing such primes as rule, rule-order, and derivation.[3] This is the argument from acquisition, to which I now turn. However, since some of the kinds of data I shall use may be unfamiliar to linguists, let me begin by briefly outlining my procedure.

I shall first bring analogs from simple natural motor-command systems, for the notions: train of processes, executive command of processes, and reciprocating and reverberating processes. It is in terms of the very special constraints that human language places on the use of these simple elements that an attempt will then be made to show what is uniquely human, and moreover unique in human cognitive processing, about the notions 'ordering or processes' and 'derivation', at least so far as phonology is concerned.

2. Trains of processes.

A major assumption of generative phonology is that the alternative realizations of non-suppletive forms in fact share common (sometimes quite abstract) underlying representations, to which they are separately related by (sometimes quite lengthy) trains of rules or processes. The strongest claim (Cf. 1.2.1 above) about such rule or process-trains would be that, when properly chosen, their contents and order are psychologically real (e.g., can be brought to consciousness by suitable techniques) and that they operate in real time when we speak--though of course this does not mean that all rules correspond to muscle-commands, a question which will be returned to (sec. 4 below).

2.1. Central command of process-trains.

We first seek an analog for trains of processes commanded by individual segments of representations. Such an analog is not hard to find in lower organisms. Thus, in some kinds of arthropod, ordered motor outputs may be released by activity in single central (inter-) neurons. Take for example the control of the postural

muscles in the abdomen of the crayfish. On one side of a given abdominal segment, the mutually antagonistic slow extensor and flexor muscles are each supplied with six efferent neurons, five motor and one inhibitory. The flexion command, for instance, then seems to involve not only excitation of the five flexor motoneurons plus the extensor inhibitor, but at the same time inhibition of the five extensor motoneurons plus the peripheral inhibitor to the flexors. The cyclical discharge of the whole reciprocating system, consisting of over 120 efferents, is controlled by the discharge of a single central cell (Kennedy, Evoy, and Hanawalt, 1966).

To generalize this to a phonological rule-series is not difficult, though it may be hazardous: it is possible for a central segmental representation (say, in a single central neuron) to trigger an executive command for a whole train of processes (e.g., a derivation for that segment), locked to the identity of that central neuron.

2.2. The content of process-trains.

Centrally triggered trains of behavior characteristically contain reciprocating and cyclical elements, in addition to simple non-repetitive elements.

A good example of a cyclical reciprocating system is the posture control system in the crayfish described above. For the child's production system, the dominance of reciprocation (e.g., CV-syllable structure), and reverberation (e.g., sequences of identical syllables) is obvious from the structure of babbling and early imitations: the command unit seems to contain the reciprocating syllabic gesture, while the command train seems to consist of repititions of the same complex gesture. We find babbling sequences of the structure [ba-ba-ba] or [da-da-da], but never for example an alternating sequence such as *[bi-ba-bu].

The vowel and consonant harmony of somewhat later child language attest the continued importance of this pattern, whose reflexes are also important in the structure of adult language: we continue to find cyclic processes, both in the simple circumstance of vowel-harmony and at the higher level of integration required for cyclical stress-assignment.

A more complex example, containing both repetitive and non-repetitive elements of behavior under central control, is the pre-skin-shedding activity of the giant silk-moth (Truman and Sokolove, 1972). In response to a signal from a photoreceptor in conjunction with a biological clock, a hormone is produced. This hormone activates a centrally-generated train of behavior lasting well over an hour. Two main periods of activity are defined, each containing a repeating chain of reciprocating movements; first, a period of abdominal twitches, and second a period of peristaltic waves.

Clearly, the information for complex cyclical and reciprocating process trains (say, phonological process trains) may be preplanned in the nervous system, to be run off on receipt of the appropriate neural or endocrinal signal.

3. Mentalized processes in trains.

But the analogs are still quite unsatisfactory in a number of respects. Of most immediate importance here is the fact that, as distinct from the systems referred to, a train of processes applied to a given segment in phonology does not result in a corresponding train of overt motor activity. Rather, only the segment-representations available at the output of the final process can be the basis for signals to the appropriate cranial nerves and thus commands to the speech tract. Leaving aside for the moment the problem of stylistic (including fast-speech) variation, let me illustrate with an unambiguous example: thus, in 'divine' neither the underlying /ī/ nor any intermediate stage, but only the final output /ái/ is responsible for a signal for tongue-movement. The claim remains, that is, that the discharge to the final common command path (the cranial nerves) is under the control of the central neuron representing a particular linguistic segment. But there is a special constraint on the system that scans the space-pattern of the central system for language (Cf. Lashley, 1951); peripheral excitation is suspended until the entire process-train has been scanned.

It would seem of importance to considerations of innateness in language acquisition, that it is difficult to find any analog in the lower systems for precisely this last quality, viz., the constraint 'excite the final output only' (cf. 3.1.1).

3.1. Models and the abduction of order.

In the light of the mechanisms suggested, and of the constraints under which they seem to operate, at least two models suggest themselves to account for the occurrence of ordered processes as a natural product of language-acquisition. Both these models account not only for derivations, but also for the dramatic contrast in control abilities as between babbling, with its inventory of 'all possible sounds', and early speech, with its near-total poverty of inventory. Each corresponds to one of two important ways in which a neural system may be internally modified during maturation, viz., (1) by changes in existing programs due to radical modifications in levels of endogenous excitation, and (2) by the release of new programs as such, though utilizing existing network activity.

3.1.1. Changes in existing programs.

The first model assumes that at the stage when the cortex replaces the brain stem as controller of vocalization (cf. Drachman, 1970), inherent patterns of motor-control are quite suddenly reprimed. As a result, the output system is now inflexible to all but a very narrow range of possibilities: in brief, it can produce only the maximally differentiated reciprocal motor-pattern represented by 'cv', e.g. [pa].

In this model, rule-sequences arise during maturation, as the mental quantifications of what prove to be possible routes to

diversified pronunciation. Thus, for example, at the stage when it becomes possible to produce the carefully controlled spirant f, the fact that it was 'easier' before to produce only the ballistically controlled stop p becomes coded as a process converting spirants to stops. Similarly, the greater 'ease' of p than either t or k, and later of t than k become codified as two processes converting, first k to t, and then all t (including t from k) to p. Likewise, the 'easiest' vowel at the earliest stage is that most differentiated from the most closed and minimally controlled stop p, viz., a: diversification of command, with consequent control over the most contrasting vowels i, u, again corresponds to processes laid down. This time the processes convert all vowels to a.

Thus trains of processes are laid down, each process representing, though in obverse, a single quantal jump from a maturationally easier segment to one maturationally more difficult. As command improves, these derivational-trains grow in length. But they also grow in complexity, since each improvement involves a contextual hierarchy of ease, a hierarchy which of course remains a part of the system (Cf. Zwicky 1972 for such hierarchies in adult language). Thus, for example, nasals may appear early in development. But they appear first only word-initially, and there only when all the segments following in the same word allow the velum to remain partly down; the corresponding processes laid down as the nasal is mastered for other positions and environments, will convert nasals to the corresponding consonants lacking the difficult velum lowering, i.e., stops.

It is of course to be expected, given even the present limited understanding of the complex mechanical forces of inertia in the tract, that a segment should depend to a greater or lesser extent on its neighbors. It is also beginning to be clear how the more extensive dependencies seen in child-language vowel and consonant harmony are related to the structure of the control system. But there is a third level of complexity to the problem: within mentalized process-trains, successive processes are seen to prepare segments for each other in both anticipatory and inertial fashion, so that the processes appear to 'hunt' backwards and forwards through a word. Since both local and distant-assimilation processes behave similarly in this respect, a simple example involving 'distant' processes will suffice. Consider the child-form [dog] for 'God'. The derivation involves two processes, each affecting a different segment, and the one must operate before the other; thus, velar assimilation of the second consonant creates the (also found) intermediate form [gog], but subsequent velar dissimilation of the first consonant is required to 'complete' the derivation as [dog].

It thus seems that in the acquisition period we see the natural ontogeny of process-trains; based on the quite elemental mechanisms also found in lower organisms, they show the complexly ordered contextual interactions characteristic of adult phonological systems. As with the 'output' constraint considered above (sec. 3), it is hard to find an analog for this 'hunting' property of language processes, in the control systems of lower organisms.[4]

3.1.2. The release of new programs.

It is clear from the case of the silk-moth described above, that complex process-trains can be pre-planned in the nervous system, to be released as whole programs. It might thus be claimed that just such a set of processes is triggered as a whole program, when control of vocalization is transferred to the context during maturation. The knowledge, by what quantal leaps in ability improved pronunciation will be possible, is here interpreted as a set of 'incompetency rules' (Smith, 1970) or perhaps more appropriately as 'innate processes' available to the child (Stampe, 1969).

3.2. Evaluation of models.

Insofar as it can hardly be a useful function of rules to destroy information as the natural process-train does, the innate processes must be understood not as instructions, but rather as inevitable tendencies in the tract, to be overcome as soon as possible. So far, it is hard to distinguish this from the concept that the improved pronunciation requires improved control, and that the structure of the tract and its command-system dictates the order and hierarchies of improvement.

On the other hand, the notion that processes are 'laid down' would imply that they are not available to inspection in the first place. This makes the funneling function[5] of naturally-ordered processes impossible to apply to the child's first attempts. But it also fails to account for latent learning, i.e., learning which occurs without overt practice on the part of the child; for once we admit that pronunciation difficulties may be overcome in the child's mind, then why should the processes involved not simply be there (in the child's mind) already?[6]

3.3. Acquisition strategies and marked order.

It is already clear that the view of child development held here is hardly mechanical. And in fact, the more difficult concept of 'marked order of processes' can hardly find an explanation without allowing for a quite creative view of the child's development, one which in principle allows for the intervention of developmental strategies.

Let us assume the innate process-train and its (natural) ordering. Then, there can be relief from the catastrophic cumulative consequences of the operation of this process-train only if it can somehow be interrupted. The first type of interruption, Stampe's partial or total suppression of some process, presents no problem here; it corresponds straightforwardly to the notion of command-maturation, and of course implies immediate improvement in the relevant segment in all applicable forms.

But there are at least two other ways in which the child may circumvent the massive homonymy created by his own incompetence; insofar as these resemble 'deliberate' attempts to go beyond systematic ability, it may help to look on them as strategies

for the preservation of underlying information. The two strategies I refer to are 'Use whatever temporary mechanisms you can', and 'Replace a vulnerable segment by a less vulnerable one if you can'.

3.3.1. 'Use whatever temporary mechanism you can'.

This strategy in fact generates three kinds of artifact of interest in phonology generally. The simplest of these is that segments may have unusual context-free allophones, as when a child first produces [sok] for both 'shock' and 'sock', and then suddenly disengages s̆ from s by producing [ɬok] and [sok] for the same forms.

More importantly, the result of this allophonic process sometimes appears to mimic a segment not presently pronounceable in its own right. For instance, the Velten child (Velten, 1943) at one stage produced [but] for 'bed', but [dud] for 'train', i.e., the /d/ not pronounceable in 'bed' turns up in place of the (equally unpronounceable) /n/ in 'train'. There is some evidence (Cf. Menyuk and Klatt, 1968; Kornfeld, 1971; and Drachman, 1971) that such derived segments do not always in fact mimic the exact articulation of the impersonated segment, and may thus constitute artifects of the researcher's perception. Now perceptually-confused researchers are also adults in speech communities; it must thus not escape us that this phenomenon strongly resembles what Kiparsky (1971) has called 'opacity', viz., of the type where A, which normally gives B, may nevertheless reappear as the reflex of an underlying C.

Notice also that a sound change can easily arise through such an artifact in the child's perception. Suppose that underlying /d/ and /n/ are both problematic for the child, and he substitutes some pronunciation of /n/ which in fact acoustically resembles /d]. On mastering the nasal, he may very well retain the pronunciation of the impersonating segment, now functioning however as his regular manner of producing (not /n/ but) /d/.

The third and most important artifact of this strategy is that its results may resemble those obtainable by re-ordering naturally-ordered processes, a phenomenon I have discussed elsewhere (Drachman, 1971). Briefly, if at the earliest stage, underlying final p-b-m produce only p, then the processes supposed are the feeding pair (1) m → b, and (2) b → p. Notice that the data explained above as resulting from a perceptually confusing impersonation, could be interpreted (though, as I have suggested, misleadingly) as resulting from the (extrinsic) ordering of the two processes just given.

3.3.2. 'Replace a vulnerable segment if you can'.

The strategy of segment replacement takes us back to a quite elemental mechanism in child speech-production, that of distant assimilation already referred to. While this mechanism operates blindly most of the time, it seems that there are occasions when it is deliberately exploited by the child to preserve information. Sporadic cases occur in the data for a Greek child (Drachman, 1972b),

who, for example, produced [lilí] for [kliðí], 'key'. But stop-plus-resonant clusters in other forms of the same corpus always lose the resonant, never the stop; and similarly, intervocalic /ð/ in other forms weakens to [y] and is optionally lost between palatal vowels, but never gives the present [l]. Thus it seems that the child has chosen to preserve a trace of the intervocalic /ð/ by assimilating it to the /l/ of the initial cluster, a 'decision' that entails reducing that cluster in anti-canonical fashion in the first place. This analysis will seem the more plausible if it is noted that by the operation of 'reduction' processes normal for this child, the alternative shape for /kliðí/ would have been the highly degraded [ki].[7]

4. Real-time models.

I should like, finally, to return to the question of real-time processes and the distinction between Competence and Performance. As already pointed out above, it is of course absurd to suppose that all the processes operate within the final common path, that from the cranial nerves to the muscles of the vocal tract. Can we, to take the opposite extreme, find any evidence to support a real-time version of the Chomsky-Halle (1968) view of phonology as a seamless web of processes, viz., a version which the processes are in performance distributed along the nervous tract, from the cortex to the neuro-muscular junctions in muscles of the speech tract?[8]

For at least a good many of the processes, the indirect evidence at least does not exclude such an interpretation. I cite evidence of two kinds; that concerning the Basis of Articulation and its relation to the stylistic variations subsumed under the cover-term 'fast speech'; and that from an unusual kind of aphasia.

4.1. The basis of articulation and fast-speech.

Skilled behavior such as speech-production requires priming, that is, the setting up of appropriate ranges of tonus in (neural and) muscle-systems for maximally easeful operation in the relevant language (Drachman, 1972a). In addition to this complex priming system, the model also requires the operation of a threshold device, that is, a device by which fine adjustments are made within the range given by the Basis: this device controls the overall excitability of the system, making it more or less sensitive. I have assumed that the speech-tract control system incorporates such priming and threshold devices, and that these are necessarily programmed by the child during the acquisition process, as he hears the full range of styles (from mumbling, to syllabified dictation of telegrams) acceptable in the dialect he is learning. Both the Basis of Articulation and the threshold device are of course real-time control elements. The former guarantees the range of processes over which the tract will respond with maximal ease, by ensuring that the tract members are strategically placed and shaped; while the latter responds to 'style', and selects the proper place in the hierarchies along which these processes function.

The operation of the 'threshold device' also explains the apparent insertion of a process into a process train, as sometimes

occurs in fast speech, as an artifact of the nature of processes. For example (Zwicky, 1972), 'N-loss before t' seems a plausible natural process, in terms of the problem of velum-timing. But for English this is a submerged ice-berg type or process, that is, the Basis of Articulation for English puts an initially high threshold value on it. Only the shifting of the threshold to a lower level, as occurs in fast speech, actually exposes the tip of this iceberg and only thereafter, of course, can intervocalic Flapping occur, so that /winter/ produces [wɪɾɚ], in American English.

This kind of evidence, taken together with that for slips of the tongue suggests that at least a large number of processes operate in real time when we speak, including many that could hardly be labelled 'allophonic'.

4.2. Higher level processes and real time.

Most linguists would, however, balk at the proposal that 'higher level' processes have even psychological reality, much less real-time status. Yet the matter is perhaps not quite cut-and-dried. The data for aphasia on the whole support at least a two-level structure for phonology (Whitaker, 1971). But consider the case (ibid) of the aphasiac who typically pronounced derived forms such as degradation and practicality with the same vowels and stressing as in the underived forms degrade and practical. Whatever the interpretation given (and very few data are cited), it seems that distinctly non-surface processes of English are being suspended or mis-applied, and it follows that such processes must thus be accessible during the act of speech.

5. Conclusion

(1) Primes such as 'rule', 'rule-order', and 'derivation' may be justified in that the characteristics of phonological systems which they represent in fact present themselves in a quite natural way during the acquisition process.

(2) From the analogs presented, it is clear that certain fundamental properties of process trains are common to even the most primitive motor-command systems. Two properties distinguish process trains in language: first, the complex contextual sensitivity whereby serial processes hunt across forms, and second, the constraint that only the final output representation is relevant to the motor command system. These properties seem specific not merely to human cognition but to language-processing in particular.

(3) In such process trains, natural order in acquisition produces a Békesy-type funneling effect which accounts for the child's poverty of inventory. But clearly, maturational strategies also play an important role in determining outputs. Insofar as they may produce artifacts resembling 'opacity' and 'marked ordering' of processes, such strategies bear on questions of sound change, as well as on the nature of primes.

(4) There is reason to suspect that many (perhaps all) of the processes in a well-formed phonological derivation operate in real-time and are distributed without clearly marked discontinuities through the neuromuscular system.

(5) Finally, if the primes of phonology are definable at least partly in terms of innate and maturationally inspired mechanisms of performance, it is perhaps timely to re-appraise the commonly-drawn distinction between Competency and Performance.

Footnotes

1. This paper will appear in the Proceedings of the 11th International Congress of Linguists, which was held in Bologna-Florence Aug.-Sept., 1972.

2. At this level of inquiry it might be claimed, for example, that the person desinences for the simple Present and Past tenses of the Modern Greek verb are underlyingly -m, -s, -t for the 1st, 2nd and 3rd persons singular, despite the fact that these consonants are never realized in the case of the 1st and 3rd persons--one says, for 'I want, he wants', thélo, théli, and never *thelom, *thelit. The formal ground for the analysis would then be (a) that the Middle Voice does require these desinences, and (b) that the 'lost' desinences are in fact deleted by a (long-standing) rule of Greek for the deletion of all final consonants save s, n.

3. In this framework, empirical questions can and must be raised concerning the nature and origin even of intrinsic ordering, pace the formal criterion in Chomsky (1965) tacitly adopted in Koutsoudas (1972).

4. Insofar as he assumes that only context-free processes are operative in early acquisition, Jakobson (1968) of course lacks an explanation or even an account of this most important phenomenon.

5. Békesy (1967) was of course describing sensory, not motor inhibition, and to this extent the comparison may be misleading. On the other hand, the analogy itself suggests we consider the alternative view: thus, we might consider whether funneling is due not to active processes but to inhibition processes. In that case, diversification of pronunciation would consist not in suppression of processes but rather of de-inhibition.

6. The present case thus constitutes an interesting example of the conflict between innateness and reductionist views of language acquisition. The evidence here adduced seems to support the innateness view, though only marginally.

7. It is tempting to connect this phenomenon--that is, that individual processes do not always operate blind to their own output--with its analog in adult-phonology analysis, viz., the Derivational Constraint, here seen in very general shape.

8. A rough calculation of the real-time requirement for a Performance model was first offered in Reich (1968). Basing

himself on reasonable (if meager) facts about transmission and synapse-times in interneurons, Reich suggested one could have some 1800 neuron-processes per second: that is, at 9 CV-syllables (or 18 segments) per second, a maximum of 100 processes per segment. So long as one does not require the whole phonological system to apply cyclically to individual segments, there is no objection here to a real-time traversing of the whole system, even assuming that all rules are sequential: after all, no phonological system so far described has contained anything near as many as 100 sequential processes.

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Generative Phonology and Child Language Acquisition[1]

Gaberell Drachman

1. Introduction.

To be able to pronounce acceptably the words of his native language, the child must acquire the voluntary and systematic use of his vocal tract, in the face of its many complex predispositions to reduce his efforts to homonymy. Attempts have been made to formalize both the source of this massive homonymy and the maturation stages by which it is undone, in terms of the operation of trains of processes (for the initial stage) and their unlearning (for the development). Smith (1970), the first to analyse a corpus in such a manner, called such processes 'incompetency rules', and likened their operation to that of a filter, to be unlearned as the child approaches the adult model. Meanwhile Stampe (1969) had independently made the same claims with the additional assumption that the processes are indeed innate, and asserted that they are either limited, suppressed or ordered, in the approach to the model language.

But such an account of acquisition, though it closely parallels the generative model widely adopted to account for the phonology of adult speakers, fails to distinguish between the child's passive advances in pronunciation due to increased command over coordination in the vocal tract, and the creative (though sporadic) efforts made by the child during development to undo some of the worst results of his incompetence.[2]

I have elsewhere discussed two such developmental strategies; the strategy of avoidance, and that of vicarious production mechanisms (Drachman, 1971). The first consists in the systematic avoidance of forms (as perhaps also the deletion of segments) presenting especially intractable production problems. The second consists in the temporary adoption of some alternative production mechanism which provides a closer acoustical match for a given segment of the model language than the child's own best 'proper' effort could produce.

However, a third possible strategy consists in the exploitation of a special kind of context-sensitivity, that producing vowel and consonant assimilations across syllables. These are the processes which I shall hereafter call 'long-domain processes.'

The rest of this paper is devoted first to a discussion of the ontogeny and form of such long-domain processes; then, in indicating their place in phonology, I shall show how they interact with substitution processes, and how this interaction may be exploited by the child.[3]

2. The ontogeny of long-domain processes.

At the early stage of child-development characterized by Babbling, the motor-command system for the speech-tract seems able to deliver only a rhythmically repetitive sequence of identical syllables, each consisting of a single pair of extremes of articulatory activity--thus, CV + identical CV, etc., where C is a bilabial or dental stop, and V an open vowel. This pattern has been attributed (Drachman, 1970) to a dominant neurophysiological substrate involving two common types of neural circuitry; a reciprocating type, producing alternating activity in mutually-inhibiting muscle-sub-systems; and a reverberating or closed-loop type, producing simple repetitions of this alternating activity.

Later stages of vocalization show the slow inhibition of this dominance which, however, continues to affect the output. This may be seen in the deletion of final consonants, the breaking up of clusters by simplification or vowel-insertion, as of course in the so-called reduplicating forms, all common to child language.

Now that detailed histories for individual children are becoming available, it is clear that, before the autonomy of successive syllables and the segments they contain is well established, there is a period during which both the anticipatory and the inertial influences of one syllable on its neighbor are pervasive. This is the period of the long-domain processes, a period varying from child to child and during which the course of maturation of articulatory abilities continues on its parallel way.

3. The form of long-domain processes.

Considered taxonomically, the long-domain processes I shall survey comprise syllable-harmony, vowel-harmony, consonant harmony, syllable-gain and syllable-loss, and metathesis. However, it will become clear in what follows that such a taxonomy is unrevealing, and that (for example) most putative cases of syllable-harmony and syllable-loss are probably best analyzed in terms of multiple processes.

3.1. Harmony.

Corpus (1) Syllabic harmony.

kuneláki → kulaláki	rabbit
filipáki → papáki	Philipaki (name)

Corpus (2) Vowel harmony.

kutáli → kotáli	spoon
lemóni → mamóni	lemon
potíri → potúlri	tumbler
maxéri → mayáyi	knife
piróni → pulúni	fork
ðulítsa → vilítsa	work

Corpus (3) Consonant harmony.

kliδí → lilí	key
kapélo → papélo	hat
lemóni → memóni	lemon
aftó eḱí → akoḱí	that (over) there!

Consider the forms under corpus (1) above. It is at first sight plausible to hold that these forms illustrate syllable-harmony; i.e., that a whole syllable has been assimilated to its neighbor. But from the forms of corpora (2) and (3), where we see the component processes at work separately, we can reasonably deduce that a form like that for 'rabbit' (Corpus 1) has in fact undergone both processes--as I shall later show more convincingly.

The forms for 'spoon', 'lemon', 'tumbler', in turn show that vowel-harmony may work by degrees, i.e., that it need not involve all the potentially affectable distinctive features of the segment concerned. In 'tumbler' moreover, the harder question arises whether harmony can operate not merely by inertia (which seems uncommon) but may even affect a stressed vowel. However, the case is equivocal: comparing the form for 'knife', it is plausible that in 'tumbler' as well as there, we have to do with the 'backing' effect of a following /r/,[4] here behaving very much as a laryngeal (Cf. Drachman and Malikouti-Drachman, 1971).

3.2. Syllable-gain.

The tendency for the substrate command-system to produce open syllables is of course not supported word-internally in Modern Greek, which permits many internal clusters. On the other hand, word-final consonants are (at least in the inherited vocabulary) seriously constrained, only /s, n/ being permitted, except in Biblical names. Thus, while the additional medial (open) syllable in 'knife' (corpus 4 below) is a canonical type of perseveration, the prosthetic initial vowel in 'mouth' is unexpected.

Now it is unlikely that this vowel in fact represents the (mistakenly Masculine for Neuter) Definite Article {o}; at this stage the child never used the Definite Article. A plausible, though more complex solution, might be to suppose that initial pre-consonantal /s/, usually lost via [h], here vocalizes at that stage, thereafter giving [o] by harmony with the following stressed vowel.

Corpus (4) Syllable-gain.

maχéri → mayayǽi	knife
stóma → otómo	mouth

However, the fact that the corpus contains (prompted) forms such as [alávi] for [láδi] 'oil' make this alternative less than convincing, and prosthetic vowels must be considered as produced by further (not well understood) processes.

3.3. Syllable-loss.

I come now to the problem of the so-called loss of syllables in child language. Considering corpus (5) below, one must first dispose of forms like those (5.a) for 'flower' and 'snail', which have clearly lost syllables but which are equally clearly not candidates for a 'syncope plus cluster-reduction' kind of analysis. Both forms in fact show semi-vocalization, rather, with subsequent loss of an intervocalic semivowel; and each form shows in addition individual processes such as vowel-harmony (for 'flower') or vowel-nasalization (for 'snail').

For the remainder of the forms here, however (5.b), the question arises whether apparent syllable loss is to be straightforwardly attributed to the 'syncope plus cluster-reduction' syndrome, or whether more mysterious factors are to be invoked--factors such as faulty representation due to inadequate perception, as has indeed been suggested (e.g., in Ingram (1971) overtly, and Garnica (1971) by implication).

Corpus (5). Syllable loss.

a.	lulúði → lulú	flower
	salingári → ãgáli	snail
b.	trapézi → péyi	table
	domáta → máta	tomato
	lemóni → móni	lemon
	lekáni → káni	basin
	sirtári → táli	drawer
	ðikómu → kómu	mine

3.4. Digression on perceptual testing.

Perceptual testing hardly seems today in a sufficiently advanced state to contribute seriously to the problem as to whether and how the child's acoustical representations might be systematically deficient or distorted.

It was first suggested by the Russian psychologist Shvachkin (1948) that children acquire the perceptual distinctions required to understand their native language in an order similar to that proposed independently for language-production in Jakobson (1941). This raises the fundamental problem, whether advances in production ability are in any simple way dependent on the development of perception. Even Garnica's promising replication of the Schvachkin tests (Garnica, 1971) fails to address itself to this crucial problem, for which it would have been necessary to carry out tests of spontaneous and prompted production for each stage of perceptual testing. In the end, the datum which must be explained by anyone holding that perception is seriously involved in the problem of production development is this: from Jespersen (1941), through Leopold (1947) and Smith (1970), the claim is found that a contrast newly produced for a given pair of segments is immediately applied

to those segments in (almost) all and only the relevant forms--and that those forms have of course not all been re-heard across the period of improvement.[5]

For the moment, the simplest working assumptions would seem to be the following. (1) With one important exception (2 below), what is in principle registered by the child is the adult surface shape of the word. The resultant Primary acoustical representation (Drachman, 1971) may, however, at once be somewhat more abstract than one consisting simply of surface allophones, certainly for segments exhibiting stylistic low-level alternations (fast-speech variants, etc.); and this may be true perhaps even for segments not exhibiting such variants, as Stampe has suggested (seminar 1972).

(2) The exceptional case is that of certain types of acoustical confusion: such are that obtaining between spectrally similar continuants such as f - θ (Cf. Tikofsky and McInish, 1968; Abbs and Minifie, 1969), and the confusions of ordering found in experiments on adults (e.g. Bond, 1971), especially in clusters containing a continuant and a stop consonant.

(3) Particular words may have inadequate or inaccurate representations, for a variety of causes. In frequently used words, adult adoption of a child's form might lead to replacement of the child's primary representation. Conversely, the acoustical representations of very infrequently heard words (especially polysyllabics) may be replaced by the feed-back (again acoustical) representation of the child's own defective output. I have the impression that it is also true that children sometimes, having 'decided' on a word's shape, simply fail to hear it correctly thereafter.

3.5. Metathesis.

The phonological status of metathesis has been much disputed, especially as a synchronic process (see for example Kiparsky (1967), but compare Webb (1971)). In this context, it is of interest that only sporadic cases of possible metathesis are found in the present corpus. On the one hand, some putative cases prove to be analyzable as resulting from multiple processes. On the other, a small residue of cases seem genuinely to involve metataesis, sometimes (Cf. corpus 9, for prompted forms) of whole syllables.

Consider the brief sample in Corpus (6) below of spontaneous forms involved.

Corpus (6) Metathesis in spontaneous forms.

kuneláǩi → kulenáǩi	rabbit
ksipóliti → tóliǩi	barefoot (plural)
síδero → lítoto	electric iron

The form for 'rabbit' above might be analyzed in terms of successive assimilation and dissimilation of resonants. The form for 'barefoot' is more complex, but again no metathesis seems required. If the vowel of the first syllable is syncopated (and

pre-tonic vowels are particularly prone to syncope), the resultant cluster will collapse; the surviving consonant (whether /k/ or /p/) then assimilates to the common articulation point of both following consonants. Lastly, the /t/ of the final syllable is palatalized by the following /i/, as is regular for the corpus.

However, 'electric iron' is problematic. It seems that the resonant [r] of /síðero/ has metathesized with the initial /s/; even in its new position, however, /s/ gives [t] (regular for the corpus). This gives us the intermediate form [ríðeto]. Initial /r/ now (regularly) gives [l], in parallel with which the medial consonant and following assimilate respectively to the final consonant and vowel. Notice that these assimilations must bleed the processes normally leading to the loss of [ð] in such a form.

4. Long-domain processes and phonology.

4.1. General.

There is a long-standing debate as to whether the rules contained in a phonology do in fact constitute a seamless web--as implied in the formulation, e.g., of Chomsky-Halle (1968)--or whether there is not some difference in status between (say, in English) the Vowel Shift and Palatalization, i.e., as between abstract rules and living phonetic processes.

That there may after all exist a natural break in the rule-series has in particular seemed supported by the evidence from slips of the tongue (Fromkin, 1971), those adult-language processes, also sporadic, most reminiscent of the long-domain processes discussed here. It has thus seemed worthwhile to pursue the parallel.

4.2. Long-domain, and other processes.

Now it seems that, since morpheme-structure conditions and rules for contextual variation always survive a 'slip of the tongue', the relevant 'slip' processes must take place at the interface between those conditions and rules and the so-called central rules of the phonology--say, in some kind of buffer short-term memory in which utterance fragments are presumably stored in preparation for transmission to the speech tract via the cranial nerves.

If long-domain processes are akin to 'slip' processes, then it ought to be the case that they too constitute a single sub-component of the phonology, again perhaps preceding the supposedly 'lower-level' rules. I shall here test this hypothesis by suggesting suitable rule derivations for typical forms in which long-domain processes are seen to operate.

Consider the proper derivation of the form for 'rabbit' in corpus (7a) below. First, notice that Consonant-Harmony and Lateral-palatalization[6] may operate in either order, equivocally so for the principle at stake. On the other hand, palatalization of /l/ must occur while the underlying /e/ follows it, i.e., before vowel

harmony, which makes this /e/ a back vowel. Thus at least one low-level processes precedes vowel-harmony, which is of course a long-domain process.

On the other hand, vowel harmony must here follow palatalization, for we should otherwise not have palatalized [ĺ] at all. And the occurrence of palatalized [ĺ] proves beyond doubt that the underlying representation in fact contains the correct vocalism (viz., /e/), since back vowels do not of course provoke palatalization. I shall revert to this matter below. For the moment, it is clear that the putative parallel between long-domain processes and 'slip' processes is not sustained: on the contrary, long-domain processes seem to interdigitate with low-level processes, at least in child phonology.[7]

Corpus (7) Local ordering.

(a) 'rabbit'		(b) 'automobile'	
	*kuneláḱi		*aftoḱínito
Cons. Harm.	kuleláḱi	Vow. = loss, & Cluster-red/n.	tokínito
Palat'n (i)	kuĺeláḱi		
Palat'n (ii)	kuĺeláḱi	Vow. Harm.	tikínito
Vow. Harm.	kuĺaláḱi	Palat'n (i)	ćiḱínito
		Palat'n (ii)	ḱiḱínito
		Vow./Cons. Harm., etc.	ḱiḱínano

Consider next the derivation for the form 'automobile' (corpus 7b) which involves the same pair of processes, viz., vowel harmony and palatalization. I assume first vowel-loss plus consonant-cluster reduction in the initial syllable. Then, in accordance with the earlier discussion, I reject syllable harmony in favor of a series of processes affecting single segments; here vowel-harmony is the only long-domain process required, for it naturally feeds two perfectly regular processes, viz., t → ć, and ć → ḱ (compare [ḱia] for /tría/ 'three', and [ḱéla] for /stéla/ 'Stella' in the same child's speech).

But it is now obvious that the two processes of vowel harmony and palatalization must operate in opposite orders for the two derivations compared (viz., 'rabbit' and 'automobile'). In the present cases, the natural (i.e., feeding) order is that vowel harmony should precede palatalization, as it does for 'automobile'. But in the case of 'rabbit' palatalization would in fact be bled by vowel-harmony. Assuming that both processes must inevitably operate in this form, it seems that their ordering is reversed so as to preserve at least the information that the underlying vowel in the affected syllable was a front vowel. This seems to confirm the naturalness of the principle of 'local ordering' of phonological processes (Anderson, 1969), a principle according to which unmarked shapes select suitable derivational orders.

5. Prompted forms.

The data presented so far represents only spontaneous utterances. But, as was noted in an earlier mention of this data (Drachman and Malikouti-Drachman, 1971), prompting was quite frequently employed to elicit or re-elicit forms. Such prompting and repeated prompting often elicited variant forms of considerable interest. However, the Pandora's box of methodological problems that this opens requires special comment, before discussion of the forms themselves and their relevance to the status of the long-domain processes.

5.1. Factors affecting imitative behavior.

It is obvious that one may unwittingly disrupt a person's (expecially a child's) performance of a skilled act simply by either asking him to repeat it or showing him how to do it and asking him to copy you. I summarize below some of the conditions for successful imitation, as well as some of the factors that may impair it.

Some positive factors are: set to imitate, boldness to hazard errors, and present ability in spontaneous activity. A prompt following silence (avoidance by the child) offers a model, and the encouragement to respond; while a prompt following an attempt by the child not only suggests that improvement is possible but perhaps does so at the maximally useful moment--compare the similar function sometimes attributed to adult sentence-completion (e.g., McNeill, 1966).

Some corresponding negative factors are: prompting may dissolve the naturally vulnerable self-confidence of the child, or simply bore him into silence; or, if the child adopts a 'rote-repetition' strategy, priority or recency effects may appear--indeed, repeated prompting for the same word may even create hallucination effects, the child searching the form in different ways or in alternant directions at each hearing. Further, it is difficult (perhaps impossible) to ascertain when or even whether a given word has been heard before, which of course calls into question whether the child's representation is from long or short-term memory. Then too, blends may occur, as a result of perseveration of interest from an earlier stimulus (picture or question).

Lastly, there is the problem of 'proximate ability' referred to by Vygotsky (1962); if the system is 'ready' for improvement, we may in repetition tasks be tapping a slightly later stage of ability. It is worth noting the perhaps sanguine assertion of Smith (1970), that whenever prompting was successful the improvement thus foreshadowed was always achieved within quite a short time.

5.2. The prompted corpus.

Having sketched in gross outline the difficulties in interpreting the results of prompting, it remains to add that the child concerned was rarely overtly disturbed by the procedure, save to syllabify an occasional form back at the investigator in a loud exasperated voice. Also, she occasionally balked at 'difficult' words, including her

first name Chrisa ([xrísa], readily repeated as [ǵíta] a month later) and her surname Philipaki, to which I shall return at the end of this paper.

In what follows, only two kinds of prompting are distinguished; prompting for repetition of a spontaneously uttered form, and prompting to elicit a known form at which the child hesitated. Some attempt is made to correlate particular kinds of 'error' with individual factors of the kind surveyed above: more important, the special status these forms must have (compared with those elicited spontaneously) is characterized in terms of varying degrees of complexity of phonological derivation.

5.3. Prompting. Repetition of spontaneous forms.

Corpus (8) below displays in parallel columns the range of response-types elicited as prompted repetitions of the corresponding spontaneous forms.

Sub-corpus (a) shows that some forms may be characterized as stable under this kind of stress. The stability of the medial glide [y] for underlying [ð] shows us the edge of a hierarchy, for between front vowels, or even between high vowels (cf. 'flower' in sub-corpus (b)), this glide is elsewhere optionally lost.

Corpus (8) Prompted repetitions.

	Adult form →	Spontaneous →	Prompted Repeat	
a.	póði	póyi	same	foot
	sirtári	táli	same	drawer
b.	lulúði	lulú·	loló·yi	flower
	trapézi	péyi	papéyi	table
c.	kapélo	papélo	pélo	hat
	ráðio	yá·yo	áyo	radio
	trapézi	péyi	papéyi-apéyi	table
d.	kapélo	papélo	?pélo	hat
e.	parakaló	pa·kaó	kaloló	please

Sub-corpus (b) shows the kind of improvement all well-behaved prompted forms should illustrate, in these cases the restoration of a 'lost' syllable. Note that the loss in 'flower' is not an (uncanonical) example of the loss of a post-tonic unstressed syllable; the final vowel is 'lost' only in the case that glide-loss leaves behind a vowel-sequence, whereupon vowel assimilation (and optional contraction) occurs.

For any case of a restored segment or syllable on prompted repetition, the question arises whether the child's stored production representation has been affected. It is legendary among researchers, and true for every case here, that no permanent modification in

pronunciation results from prompting; the earlier form re-appears again in later spontaneous utterance, even within the same interview (e.g., the treatment of the name Philipaki, section 5.4 below, and cf. Templin (1966); but for syntax cf. the sanguine view on sentence-completion in section 5 above).

Not surprisingly (cf. section 5.1 above), regressions occur under prompting conditions. However, Sub-corpus (c-d) contains an interesting contradiction.

Take first the story of 'hat'. If, following the information-preservation theory of the function of rule ordering discussed in 4.2 above, we hold that consonant harmony in the spontaneous form [papélo] helps to preserve the unstressed syllable, then we should claim that the inhibition of this harmony under prompting is followed by loss of the unstressed vowel, with subsequent reduction of the resulting cluster in *[kpélo]. The intermediate form [?pélo] under (d) seems to fully confirm this (previously mentioned) view of syllable loss, the relevant derivation being:

1. Loss of unstressed vowel ... [kpélo].
2. k gives ? before a dissimilar stop ... [?pélo].
3. Cluster reduction ... [pélo].

However, the alternation, for 'table', of [papéyi] with [apéyi] suggests at first sight that we must perhaps also recognize the occurrence of simple loss of initial consonants. But the evidence is not unequivocal here. The corpus also contains forms such as [alávi] for /láɓi/ 'oil' (cf. section 3.2 above); that is, there appears an occasional inexplicable prosthetic vowel, so that we might assume that [apélo] also contains such a vowel.

A complex kind of regression under prompting is seen in sub-corpus (8e). It is obvious from the spontaneous shape that the child's underlying form for 'please' is essentially that of the adult: in this form, however, /r/ has (regularly) given [l], whereupon the two [l]'s semi-vocalize and are then lost between back vowels.

In the prompted repetition, on the other hand, the immediate acoustic image has apparently 'saved' the [l] in the stressed syllable from semi-vocalization and loss; the unstressed syllables have, however, undergone the further processes of velar harmony and following lateral-harmony, vowel-harmony and vowel-simplification. The parallel derivations are;

		Spontaneous		Prompted repetition
1.	/r/ → [l]	palakaló		palakaló
2.	semi-vocalization	paɥakaɥó	but	paɥakaló
3.	loss of s/v	paakaó		paakaló
4.	velar-harmony			kaakaló
4.	Lat-Harmony, V-Har. & V-simplification.			kaloló

5.4. Prompting of avoided forms.

The child may avoid responding for any of a number of reasons, some of which are implicit in the discussion above (section 5.1). Of linguistic interest is the fact that persistent attempts to elicit such forms by prompting often produces data 'richer in processes' than either spontaneous utterances or prompted repetitions do. Consider first Corpus 9 below.

Corpus (9) Metathesis in prompted forms.

a.	búka → gúba	mouth
	tsungrána → gudána	rake
b.	layuɓáǩi → ɣulaváǩi	baby hare
	mikrófono → konítoto	microphone
	tsekúri → kutíᵊli	axe
c.	pondikáǩi → gokabé·to ~ gubadáǩi	mouse

As was shown above (sections 3 and 3.5), complex substitutions are often best accounted for in terms of multiple processes. Corpus (a) above contains forms of this kind; we suppose that assimilation and subsequent dissimilation gives (e.g.) [búka → kúka → kúpa → gúba] for 'mouth', while 'rake' undergoes slightly more complex shifts but in principle behaves similarly.

On the other hand, the forms under (b) all contain a velar in the second (and apparently dominating) syllable: but it would in fact require quite ad hoc rules, viz., one per form, to adjust the output of velar harmony to produce the attested shapes. It seems unavoidable, since not only the consonants but also the vowels appear switched in position, that these are genuine examples of metathesis, and syllable-metathesis at that. Even more complex metatheses are seen in 'mouse' (under c), both versions seeming to involve transposition of velars to the beginning of the word.

Last, consider the problem of 'fossil' forms, i.e., forms fixed at some (early) stage of phonological development, and by-passed by other forms of similar shape. Adoption of a particular 'quaint' shape by parents often seems to have this outcome for the word concerned. Take the case of 'Philipaki', the child's surname. As will be seen from the sub-interview (corpus 10 below), four distinct shapes, including one 'correct' version, were elicited through four prompts, after the initial failure to respond. The three 'defective' forms (b, d, e) are of special interest.

Corpus (10) Sub-interview.

	Researcher (translation only)	Child response
a.	What's your name?	(no answer)
b.	Philipaki! What's your name?	[papáǩi]

c. Philipaki! What's your name? [filɪ̌páḱi]

d. What? [fi·káḱi]

e. Philipaki! Say it again. [fiḱáḱi]

f. (Some 20 minutes later) [papáḱi], spontaneously.

First, there is no question of a syllable deletion for the medial /l/--the semivocalization of /l/ between palatal vowels is perfectly regular for the corpus, as is the (optional) contraction of identical vowels that follows it. Second, since initial /f/ is attested elsewhere in the corpus, it is difficult to attribute any kind of information-conserving function to the vowel and consonant harmony resulting in [papáki], the child's stable spontaneous form. We are thus driven to the conclusion that [papáki] is probably a fossil from the earlier stage, one at which harmony did in fact preserve information. That the child's parents used the same form to the child tends to confirm this suggestion.

There remain the two forms [fi·káḱi] and [fiḱáḱi]. Under the immediate influence of the prompt, the 'fossil' is abandoned temporarily. Now we see velar harmony, (unusually) affecting the consonant in the stressed syllable. The two processes of palatalization and consonant harmony again alternate in order: if harmony precedes, [fikáḱi] results; but if palatalization precedes, later harmony reproduces the palatalized [ḱ], giving [fiḱáḱi].

But the ordering alternation here is not between different forms (as in the case of 'rabbit', as against 'automobile', earlier); for the same form appears with both orders. Neither does the non-feeding order in [fikáḱi], on the other hand, seem to conserve information in any way; both processes and orders are effectively 'blind' to the output. It must thus be the case that ordering of processes is unstable in early language acquisition. It may indeed be this very instability that enables the child to discover the information-preserving function attributed to the principle of local ordering of processes.

6. Conclusions.

This paper illustrates an important way in which the child creatively partakes in his own phonological development. The particular developmental strategy discussed is the use made of 'long-domain' processes, processes whose ontogeny is held to lie in the developing speech-tract control system. Such processes seem to contrast with the apparently similar processes characterizing 'slips of the tongue'; in particular, the former interdigitate with so-called low-level processes.

But the interaction of long-domain and low-level processes seems sporadically subject to functional control by the child, the function served being apparently the conservation of information, mediated by 'local' ordering of processes in the sense of Anderson.

From prompted form, which illustrate the extreme range of additional processes, it seems that ordering of processes is flexible during early stages of the child's development. It is suggested that this flexibility enables the child to discover and employ the principle itself of local ordering.

Footnotes

1. This paper was presented at the Zweite Internationale Phonologie-Tagung, Wien, September, 1972, and will appear in the proceedings.

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2. The claim that normal developmental improvements in pronunciation may be supplemented by creative strategies can be tested only by compiling individual case-histories, and then scrutinizing especially those data which seem to contradict the overall developmental trend, child for child. To this end, the present study presents data from only a single child, at a single stage of development in a monolingual environment; in fact, a little girl of some 27 months growing up in Athens, Greece. The corpus contains some five hundred utterances.

3. If long-domain processes have the ontogeny here supposed (section 2), they are expected to operate as blind amnesiacs, viz., without consideration either of the history of the input to them or of their own consequences. Thus we expect them to affect all relevant forms. But although such 'across the board' process-operation can sometimes be seen (e.g., in Smith, 1970), there is also much data, including the present corpus, showing only sporadic examples. In the absence of developmental studies on this point, I dare to speculate that the 'functional' use of long-domain processes occurs only during the stage when their neurophysiological basis is ceasing to be dominant.

4. It is of course the underlying /r/ that is responsible for this backing--a phenomenon hardly attributable to the surface [y]. This means of course that the form for knife is derived by the two processes (apart from the process '/x/ to [y]') backing before /r/, then glide-harmony.

5. This claim seems never to have been experimentally verified. But it would not be difficult to construct a suitable test; for example, one could use Garnica-type 'characters', withdrawing a subset from use for a period, and then re-introducing them after the relevant distinction (in, say, the first segment of their names) is perceived for the other 'characters'. At this point, the name of the re-introduced 'character' is what is to be elicited, though of course without prompting.

6. Palatalization of laterals (more generally, of dentals) is constrained in the adult language, and is provoked only by the most palatal vowel and semi-vowel (i and y). The child-form shows the wider environment 'palatal non-consonant', the natural (most general) form of the process, which she will learn to inhibit as required. Cf. [ḱéla] for 'Stella', in section 4.2.

7. It is not clear what implications there are here for the comparison with slips of the tongue. Certainly, the latter are never 'functional' in the sense claimed here, though of course neither ought one to claim that they are quite automatic--witness the fact that they are monitored during the process of manufacture, so that most 'slips' in fact are other words, often 'Freudian' in their relation to the intended word.

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On the Interpretation of Phonological Primes[1]

Gaberell Drachman

1. Introduction.

The core of an empirical science may be said to consist in the quest for two kinds of principle. The first, that of prediction (Hempel 1953),[2] is clearly insufficient in itself, as witness the ability of the Babylonians to predict the eclipse of the moon, but apparently without the support of any serious speculation on the nature of eclipses (Cf. Toulmin 1961; Hanson 1971). The second, that of explanation, surely includes the first (contra Hempel-Oppenheim 1948; cf. Scheffler 1957),[3] since explanation may normally allow prediction while the reverse is not necessarily true.

1.1. To gain precision, scope, and a high possibility of confirmation, sciences are codified as systems of concepts. But the requirement for empirical content implies a connection between these concepts and the world of experience. At least three kinds of connectivity have been postulated.

In the first (call it strong empiricism, even positivism), concepts are defined solely in terms of an observational vocabulary, whether sensory or instrumental. But in such an analysis, what would be the status of such a concept as latent learning, or any other predisposition to behavior, whether human or in the world of physics? Does magnetism disappear in the absence of an attractable object, or are the tendencies of the vocal tract absent when we are not in the act of speech?

1.2. The second kind of connectivity (call it liberalized empiricism) handles concepts--especially these troublesome disposition terms--in terms of reduction sentences, some of which prove to contain empirical laws and are thus immediately verifiable by experiment. Thus, a reductionist analysis of the disposition term 'assimilation' in phonology might contain the sentence "If a speech organ A is to be in a position Y, then it will move towards that position even while it is still taking up its prior position X", where A, X and Y are clearly definable in terms of bulk, inertia, etc., for the organ concerned.

1.3. But there are also sets of concepts (such as mass, energy) the preferred treatment of which presupposes yet a third aim for science, viz., the construction of systems of nomological relations quite abstracted from even casual explanation (Cf. Scheffler, 1957),

as a map is neutral so far as particular routes are concerned (Toulmin 1953). In such a view, the primes of a science are best handled within formal systems, i.e., as uninterpreted concept systems, accompanied by appropriate sets of postulates (definitions and assumptions). Such systems, if one requires of them only inner consistency, and no assertion be made about the properties and relations of objects in the external world, have been termed 'Euclidean' (Boltzmann 1905), where the requirement of internal consistency corresponds to Herz' (1899) criterion of 'logical permissibility'.

But in fact the 'over-kill' power and hazardous temptations available within such purely formal systems are by most scientists at least tempered by the precuation of considering the (empirically) desired interpretation at the point of choosing the primes themselves; and indeed such a version of the formal system approach seems to underlie the analysis of the phonology of English in Chomsky and Halle (1968). That the power of the 'system' has, despite the precaution mentioned, not been sufficiently checked, will appear.

1.4. If the interpretation of a prime involves assigning to it some empirical content, this may clearly be done in any of at least three ways. We may interpret primes directly, as in a positivistic science. We may, as in biology, give content to primes indirectly by interpretation of a defined term such as 'cell fusion'. Or we may, alternatively, validify our primes by appeal to the hypotheses forming part of our Postulates: in this case, what are at length tested are the deductions we make from our hypotheses or assumptions.[4]

2. Phonology as a scientific theory.

It is illuminating to consider the advantages and limitations of constructing phonology in terms of such a formal theory of primes and postulates. I shall here take 'The Sound Pattern of English' (hereafter SPE) as a representative case in point, and examine some of its primes and assumptions.

2.1. The primes of the system here are entities such as Distinctive Feature, Boundary, Rule of Phonology, etc. The postulates include definitions; such are the definitions of segment, formative, derivation, etc. They also include assumptions, of which the following are examples: (1) that the sets of Distinctive Features (DFs), Boundaries, Formatives, etc., are finite, (2) that the inputs to the phonological rules are syntactically-motivated and labelled surface-strings of (underlyingly-shaped) formatives and abstract formatives, plus boundary markers, (3) that phonological rules may modify, permute, delete, or add segments of formative representations, (4) that rules of phonology are (if ordered) linearly applied, and cannot re-apply to their own output in the same applicational cycle, (5) that all the phonological rules have equal status and are equally well motivated, and (6) that all phonological rules represent competence (i.e., knowledge, or relations, rather than behavior), but that fast speech, coarticulations, etc., are matters of performance.

2.2. The interpretation of primes is in SPE carried out in terms of performance requirements. Two sample problems may be raised here. First, systemic considerations in fact interrupt the flow-chart by which one predicts real-time outputs. Thus, adjustment of formatives (e.g., 'sing + past' → s*ng, and 'mend + past' → mend+d) must of course precede the assignment of pluses or minuses for the individual DFs within segments. But this assignment constitutes the use of DFs in their systemic or classificatory (i.e., uninterpreted) function, which thus follows a performance requirement (the so-called 'adjustment' of formatives).

Second, it is difficult to decide in principle, when 'interpretation' involves integers on DFs, and when further DFs are in fact required. A growing range of processes, and interactions between processes, has been described. It is even seen that processes may appear to be self-contradictory, with a given environment apparently provoking opposite effects in different languages, or even different periods of the same language. For example, the vowels in the neighborhood of nasals are sometimes raises, sometimes lowered; similarly, where /h/ is usually (i.e., most frequently attested as) a vowel-lowerer, there are cases (e.g., in Classical Greek, see Malikouti-Drachman 1972) where it seems to behave as a vowel-raiser.

Now while the explanations for such apparent contradictions are perhaps all to be sought in considerations of physiology and perception, it is puzzling whether the details of the explanations, whenever these come to light, need in fact to be built directly into the rules themselves, viz., as additional DFs. Pace Vennemann's (1971) explication of back-vowel lowering by coronals as relating to the backwards-slope of the body of the tongue, is a DF 'tongue-slope' to be added? Similarly, what DFs would correspond to the putative explanation for the Greek case above, that /h/ here probably partly unvoices the preceding vowel, with consequent (perceptual-based) raising?

What is not clear is whether, as the full possibilities of the vocal tract are disclosed and many further processes are isolated, the number of DF(s) required to state all processes in language will remain usefully finite. By way of providing for this eventuality in advance, one ought perhaps to consider the possibility of abandoning the requirement that the rule-format should itself contain the explanation. Without this requirement, the rules themselves could be stripped of all 'understood' detail, although (as well be suggested below, Sections 3, 5) an important distinction is required in the way in which different rules are to be handled in this respect, as well as an important enrichment of the metatheory of phonetics.

3. On the equality of processes.

One of the most important assumptions made in SPE is that all the rules postulated are of equal status and are similarly motivated. From this assumption hangs the notion, too, that the phonological component of a grammar constitutes a seamless web of rules; and it follows that linguistic significance is denied to any level between

lexical (phonological) and phonetic (uninterpreted DF) representations. The fundamental assumption, however, is not unchallengeable, as I shall here attempt to show.

3.1. In SPE, the interpretation of DFs consists of assigning an integer to each plus sign, with the implication that the values to be assigned are in fact mutually independent from segment to segment. But there is some reason to believe that an important generalization is missed by this assumption; a generalization captured by the classical notion Basis of Articulation (hereafter, the Basis). In explicating the role of the Basis in phonology, I have claimed (Drachman 1973) that there are elements in the language specific tract stance which in fact guarantee or exclude whole sets of processes, the Basis thus constituting a kind of casual principle. In this sense, the notion of the Basis is grounded in a very general principle in biology, which asserts that motor-systems may be pre-primed for specific activities, an interpretation which allows for innate (i.e., universal) as well as learned (i.e., language-specific) elements to obtain in speech-priming.

Thus there prove to be global priming elements that are probably genetic in origin, such as the re-organization of the breathing program, as well as the fact that the members of the speech-tract are pre-set at all. But there are also language-specific elements, such as the shaping and attitude of the tongue,[5] height of the larynx, height and inner tension of the velum, as well as dependency elements such as the freedom of the lips to coarticulate with a following vowel, etc. That a single element of the Basis may guarantee both positive and negative outputs (sponsoring as well as blocking processes) may be briefly illustrated from the remarks of Delattre (1953) on French, an example of which is his 'mode anterieure'.

Delattre's 'mode anterieure' may be looked upon as the articulatory implementation of a single acoustical aim, the dominance of 'forward resonance'. To this end, the tract attitude includes a convexed, downward-pointing forward-drawn tongue, with dominated (i.e., freely coarticulating) lip-rounding. A number of fine phonetic facts follow from this global tongue-lips stance. These include diverse positive factors (sponsored rules) governing the true dentality of dentals--before front vowels, the tip of the tongue is actually behind the lower incisors--the dorsal character of /r/, and the proneness of vowels to nasalization. However, the very same tongue stance also guarantees negative factors (blocked rules) such as that dental obstruents never palatalize in French, even in the most casual speech.

So far as English is concerned, the Basis probably applies for the rule series at least including and following palatalization--as confirmed by the productivity of the latter in external sandhi; and conversely, the rules preceding this series must be represented at some higher level in the control system, or simply as non-real-time rules.

3.2. Faced with such considerations, the argument appears to have swung back to the claim at first challenged, viz., that there is a natural break in the continuity of the SPE rule system. However, not only is the place of the break not the same as in the SPE claim, but it is also quite differently motivated. In particular, it is likely that a development of the theory of the Basis will support the notion that (Cf. Zwicky 1972b) there is a continuum of processes beyond (i.e., later than) those in SPE, processes explicating the facts of fast (or, casual) speech. Such a development involves consideration of how the Basis is itself adjusted to sponsor various degrees of casualness, so that rules are phased in or out in accordance with natural hierarchies.

It is important to note, finally, that the use of the term 'guarantee' in connection with the operation of the Basis must be refined. For it is not the case that all that the activation of the elements of the Basis is quite automatic: the Basis only makes the operation of the appropriate processes easeful and natural--provided they are to be allowed. This is in fact only to re-affirm the very reasonable constraint that all language processes operate quite within the limits imposed by physiology.[6] Thus, it need not surprise us to find many quite idiosyncratic exceptions to rules (whether by virtue of lexical, morphological or even syntactic constraints--cf. Zwicky 1972b),for any given language, even where these rules seem to concern very fine phonetics.

4. Phonology as a non-continuous structure.

The hypothesis that the phonological component is in fact a two-level one may in turn be tested against derived hypotheses. This assay is made partially below, with the aid of three such hypotheses.

4.1. The first derived hypothesis might be that the 'output' rules truly constitute a real-time component of the phonology, in fact an integral part of the performance component--although of course 'performance component' is not to be thought of solely in terms of mechanical organs, but rather includes also some of the 'upstream' apparatus of the neurophysiological control system.

The real-time requirement, though ill-understood in fine, may be grossly correlated with (1) brain synapse-times, (2) impulse-velocities in cranial nerves, (3) muscle-contraction times, and (4) speech-tract inertial constants. An estimate such as that of Reich (1968) may prove to be over-sanguine, failing as it does to take account of factors (3) and (4) above; but notice that this failure affects the total number of possible processes per second (and thus his figure of 200 processes per syllable) only by cutting back somewhat the number of muscle-contraction type of processes, not the number of brain processes.

In the end, it remains unnecessary to assume (pace Wickelgren 1969) that some 10^{4-6} language-specific output segments are 'stored' as context-sensitive units: there does seem to be time for these to be generated by rules that are fully supported by the Basis.

4.2. The present evidence for a divided phonology comes in the first place from the Basis, as outlined above. It seems supported too by evidence from slips of the tongue and children's secret languages, as perhaps also from some kinds of data from aphasia. But there is also a derived hypothesis for rule-systems, a hypothesis which at the same time tests the main hypothesis and acts as a touch-stone for the well-formedness of rule systems themselves.

This second derived hypothesis is that, if the rules of a phonology fall into two groups, of upper and lower-brain (hereafter, upper and lower) rules,[7] then it ought never to be the case (i.e., in a particular set of rules) that an 'upper' rule follows, or even operates simultaneously with a 'lower' one. An interesting case in point is provided by the treatment in Kiparsky (1971) and Koutsoudas (1971) of data from certain Swiss German dialects first analyzed in Kiparsky (1968).

In brief, Kiparsky describes the relation between certain forms in the (conservative) Schaffhausen and (innovative) Kesswill dialects as illustrating a putative universal of linguistic change, viz., that the innovating dialect minimizes 'bleeding' by adopting 'counter-bleeding', here for the pair of rules (here given in the 'conservative' bleeding order)

1. Umlaut, for Plural
2. Lowering of mid-back vowel before a Coronal

Noting that Umlaut is for German generally an 'upper' rule, it is clear that Kiparsky's putative universal of change presents us with a counter-case to the derived hypothesis above, viz., that 'upper' rules should never follow 'lower' ones.

It must thus be of interest to consider any re-analysis that avoids this conclusion, especially if the analysis shows other intrinsically interesting features. A candidate re-analysis is thus that of Koutsoudas, who holds that in fact the extrinsic ordering illustrated in Kiparsky's analysis of the conservative dialect is unnecessary.[8] The proffered alternative analysis assumes that for both dialects simultaneous ordering is possible, with the addition of a context-free condition (for the conservative dialect) that front rounded vowels cannot remain low.[9]

Now from the point of view of the metatheoretical constraint proposed on the ordering of 'upper' and 'lower' rules, this analysis is still not quite satisfactory, in that one each of such rules are held to operate simultaneously--while Umlaut is certainly an 'upper' rule, mid-back-vowel lowering certainly seems a 'lower' one. There seems no way out of the dilemma at the moment save to suppose that, since both rules cannot be considered 'lower', perhaps they are both 'upper'; and it remains unclear whether the analysis or the principle is what is at fault. Certainly, Kiparsky himself gives reasons for tempering the absoluteness of his principle of Bleeding-preference: in particular, he cites the need to balance against it factors such as the possibly opposing principle of phonotactic naturalness.

This case illustrates well the problem of the concept 'purpose' in scientific analysis. Whereas ethologists have in many cases established putative 'motivation' for certain innate functions in nature (e.g., the coloration of butterfly wings, the complex 'dance' of the triple-spined stickle-back), we lack adequate criteria that will enable us to extend the principle to linguistics without hazard. On the one hand, the causal principle suggested for the Basis seems a genuine example of a substantive analogy (in the sense of Hesse 1966); it suggests exactly what mechanism is at play in an experimentally verifiable situation. On the other, the principle of 'purpose' in language-change lacks this kind of verifiability and involves the delicate weighing of contradictory forces.[10]

4.3. A third derived hypothesis for a two-level theory of phonology concerns the theory of learning; there ought to be correlates at the level of neurological mechanisms, to the distinction between 'lower' and 'upper' rule and the way in which they are respectively 'acquired' by the child.

According to Piaget (1926, and passim), the child develops by the two complementary processes of assimilation and accommodation: new data are first assimilated to existing schemata, but these same schemata are later accommodated under the pressure of fresh data. In applying such notions to the data for the acquisition of phonology, one must first enquire, how the very first schemata themselves are acquired by the growing child.

The strongest hypothesis concerning the earliest schemata is that these are in fact innate, a hypothesis first proposed for phonology by Stampe (1969). On that basis (compare the debate in Drachman 1972a) some further assumptions one might make are: (1) that the child brings as 'given' a whole train of 'live' processes--corresponding to the natural predispositions of the human vocal tract, (2) that these processes in effect 'funnel' the diversity of inputs into a narrow range of possible outputs, perhaps by lateral motor inhibition (Cf. Békeśy 1967, on sensory inhibition), (3) that for a given formative, only the 'final' outcome of the process-train is a suitable input to the cranial-nerve command-system for moving the members of the vocal tract, and (4) that each individual process 'hunts' across a given formative before giving place to the following process.

Thus, for the acquisition model, the incoming data may certainly be seen as assimilating to existing schemata (here, innate), as is clear from the poverty-stricken output of the child for the earliest language stages. And it is equally clear that the innate schemata are themselves slowly accommodated to the pressure of the data. The child makes strong and creative efforts (Cf. Drachman 1971, 1972b) to undo the homonymy created by the inevitable operation of the funneling processes, and match his output to the input. Later, the relations he discovers between stylistic variants (casual, super-correct, etc.), and in paradigm alternations, etc., are slowly subsumed under ever more abstract representations, with correspondingly longer sets of rules for the derivation of complementary outputs.

There are thus at least three kinds of learning (accommodation) to be accounted for, viz., (1) that tract-command improves, so that the funnelling effects of natural (inhibition?) processes is slowly overcome (de-inhibition?), (2) that processes, or even trains of processes, may be tagged with information pertaining to morphology or syntax--a tagging that may also apply to individual lexical items viz-a-viz processes, and (3) that representations may become more abstract, so that processes must apparently be added to trains: depending on the degree of abstraction of the re-modelled representation, these may be 'lower' processes, re-activated--as in the case of the very early limited abstractization of surface phonetics (cf. Stampe 1968); or they may be 'upper' processes, if the child indeed takes advantage of every regularity in the data to 'solve' paradigm alternations such as Umlaut pluralization.

Whitaker (1971a) first suggested a possible connection between the learning abilities of the child, and the distinction made by biophysicist Jakobson (1969) between specific and non-specific neuronal connections in the brain. On the basis of research performed largely on fish and amphibian eyes, Jakobson supposed the 'wiring' of the brain to proceed in two major stages. For innate behavior (that not requiring environmental triggering) the basic wiring contains invariant connections. But for learned behavior (that requiring environmental triggering), he postulated the mediation of connections between unconstrained (non-specific) neurons, i.e., neurons requiring functional validification.

In terms of the assumption concerning 'lower' processes, we might assume that the fundamental train of these processes is laid down in terms of specific (invariant) neuronal connections, to be triggered (perhaps by a hormone) at some internally-predetermined point in time. For the learned (or, 'upper') processes, Whitaker has, reasonably, implicated the non-specific (unconstrained) neurons; these, he says, are activated at about 1 year, and constitute "the basis for native language habits".

Two problems immediately arise. First, it must be explained how, if innate processes depend upon invariant connections, they can be suppressed or even modified at all. The solution to this apparent paradox lies in viewing processes as a function not of individual connections but rather of networks of such connections. Network-internal excitability is what is indeed modifiable: it may be modified directly, by the intervention of selective-action hormones on particular neurons; or indirectly, through changes induced at synapses or neuron connections (Jakobson 1967).

The second problem is, why, if they are mediated by non-specific or modifiable neurons, do 'upper' processes cease to be modifiable as soon as they are learned? In the end, the functional analogy with the eyes of fish and amphibia may prove to be unproductive--for it is almost the case that we should prefer to have the system develop in the opposite direction, with the modifiable neurons corresponding to the modifiable processes and the unmodifiable ones corresponding to the obligatory ('upper') rules.

5. Uninterpreted and interpreted primes.

If we assert that primes ought perhaps to partake in the system as uninterpreted elements, we restore the full power available to system-emphasizing analyses. This seems to be both the strength and the weakness in the analysis in SPE, where DFs have their ill-defined classificatory function within the phonological component, but are given their well-defined phonetic (interpretive) function at the interface with the performance component. This paper has attempted to modify this position to the extent of asserting that the interpretation must in fact come earlier, since some rules (those co-opted, by the Basis of Articulation) clearly operate in real time, and thus constitute a part of the real-time or performance component.

On the one hand, some cases of the SPE use of devices such as bracketing will automatically be avoided. For example, the single (bracketed) rule for vowel Tensing[11] is in the present framework clearly two separate rules. The first is 'upper' and applies to Lax vowels preceding vowels, as in 'various: variety'--where the rule is obviously ordered before the Vowel Shift. But the second, applying to Lax vowels word-finally, as in 'hindu', is clearly 'lower'--as witness the treatment of French words with final Lax vowels, e.g., Englishized 'coupé'.

On the other hand, rules understood as 'upper' in the prsent framework are still vulnerable to such 'over-kill' devices as the alpha-convention--for example, as applied in the rules for the Vowel Shift in SPE.[12]

One solution to the problem of the over-power in the formal analysis might at first sight be to impose the interpretation requirement on all the rules (and rule schemata), for the whole phonological component homogeneously. But this carries with it the quite unwarranted implication that the 'upper' rules are in fact all properly motivated in a synchronic phonology. This is a proposition difficult to reconcile with what has been held concerning the function of the Basis; for it implies that, as changes in the Basis are historically to be associated with (even sometimes to be held responsible for) sound changes, the synchronic phonology must necessarily recapitulate all such changes in the Basis to ensure that the rules operate in plausible fashion. In the extreme case, each rule might require its own individual statement concerning the Basis, a statement to be modified for the following rule, etc.

In the end, since this last can hardly be a plausible synchronic solution, we are again left with uninterpreted primes so far as the 'upper' rules are concerned; and constraints on the abuse of the excessive power of rule schemata thus unavoidably re-introduced must be sought elsewhere--perhaps psycholinguistic experiments on young children might elucidate which schemata are reasonably operative during acquisition, as might also childhood aphasia and psychosis studies.

On the other hand, the rule-schemata for at least the 'lower' rules can be radically simplified without loss of plausibility. If the explanations are relegated to the metatheory, as suggested above

(section 2), the application or non-application of whole constellations of rules can be predicted from consideration of the Basis for the language concerned, as plausible or implausible: it will remain to state whether or not the language in fact allows these rules to operate universally or whether idiosyncratic constraints are to obtain.

6. Summary and Conclusions.

1. Three views of scientific theory are outlined, from the point of view of the way in which they handle the interpretation of primes; strong empiriciam, liberalized empiricism or reductionism, and the use of formal systems of uninterpreted primes.

2. The third of these is illustrated with a particularly well-developed example, that of SPE. But some of the assumptions constituting part of the postulates accompanying these primes are examined, on the grounds that such testing is necessary if the primes themselves are to be validated.

3. Especially challenged is the assumption that the phonological component of a grammar is a seamless web of equally well motivated rules, and that these may be followed by the Interpretation as part of the description of Performance. It is suggested instead that the real-time interpretation of DFs must obtain at latest before the end of the SPE system, and in particular from the point at which the Basis of Articulation guarantees the low-level outputs sanctioned in the language concerned.

4. Three subsidiary hypotheses derived from the assumption of a two-part phonology are then examined: (1) the time-requirement, which makes quite feasible a real-time phonology, at least for the 'lower' rules, (2) the implications for phonological change, one of which is the constraint that innovation ought never to re-order an 'upper' rule to follow a 'lower' one, and (3) speculations from neurology, which perhaps support the cognitive (Piagetian) model for the acquisition of such a phonology.

5. Finally, since it seems unreasonable to require interpretability over the whole rule-system, the problem is considered, how to constrain the over-powerful devices apparently allowable within the formal (i.e., uninterpreted) part of the phonology. It will hopefully prove possible to apply psycholinguistic tests to determine the reasonableness of particular putative rule-schemata.

Footnotes

1. This paper will appear in the Proceedings, VII Linguistisches Kolloquium (Nijmegen) 1972.

2. Except where otherwise indicated, the framework of the argument of Section 1 is essentially a paraphrase of Hempel (1953).

3. The temporal asymmetry between explanation and prediction discussed in Scheffler (1957) suggests that explanation is the more significant. But Scheffler's argument is really that neither prediction nor explanation plays a central role in science.

4. Note that the interpretation will still unavoidably contain disposition terms. This caveat, so far as phonology is concerned, corresponds to the notion that rules describe not inevitabilities but predispositions to processes--a notion to be considered in Section 3.2. Of such predispositions, the notion 'degree of probability of behavior' must correlate with what is understood of hierarchies of environment (Cf. Zwicky 1972b).

5. Shaping refers to the concave/convex/flat displacement of the tongue; attitude, to its vertical and/or horizontal displacement.

6. A claim difficult to substantiate in that it is not clear how to define fastest, or most casual, speech (Zwicky 1972a); defined in terms of the speaker's intention to communicate (Cr. Dressler 1972), even blurted speech must be included. And even blurted speech is, in appropriate circumstances, comprehensible to an involved hearer.

On the other hand, experiments in Kozhevnikov and Chistovich (1965) suggest that the degradation of fast speech forms is not the result simply of moving the articulators more quickly: rather, it seems that normal speech targets are not reached, since the articulators actually move more slowly. But this is to say that there are in fact (separate) intended targets appropriate to casual speech. This is a conclusion supported by the (mentalistic degree of stress) constraint on vowel-reduction for forms like deportation and relaxation, as against the corresponding forms like demonstration, devastation (SPE); and the (even nearer to the output) constraints on co-articulation, say, for Russian (Öhman 1966).

7. Cf., from aphasia studies, Whitaker's (1971b) 'central' vs. 'peripheral' rules. Also Cf. Stampe's parallel distinction 'dead' vs. 'live' (Seminar, Winter 1972 at Ohio State University) rules.

8. Koutsoudas is concerned with the general problem of extrinsic ordering in linguistic analysis. The evidence from child-development has been tentatively remarked upon (Drachman 1972a) briefly, it seems that phenomena resembling extrinsic (i.e., non-feeding) ordering of processes may arise as artifacts of the language acquisition process.

Note also that one case not discussed in Koutsoudas, that of optional mutual bleeding, creates a special problem. In the pair of utterances (e.g.) [fə hím] - [fər ím], 'for him', r-loss and h-loss are mutually bleeding. But it is probably the case that, even in R.P., the first version is more formal than the second; thus we must mark the orders for style, since the more casual form is not derived, as is normally the case, from the more formal one.

9. The apparent re-ordering in the innovating dialect consists, in this framework, simply in the removal of the constraint on height for front rounded vowels.

10. A parallel collision of criteria is exemplified in language acquisition. On the one hand, the child's motivation can reasonably be assumed to be to reproduce as much information as possible. On the other, the principle 'do what is easiest' dominates at least the early stages, with resultant truncated syntax and degraded formative-shapes. When, later, the two principles collide, the former is (at least sporadically) the stronger, as witness the various strategies including (e.g.) the 'use' of long-distance assimilation processes (Drachman 1972b).

11. McCawley (1972) first pointed to the illegitimate use of bracketing in this case, on the grounds that it implied an ordering constraint on one part of a rule, which in fact applied only to the other part.

12. Many re-interpretations have been attempted, as a result of widespread dissatisfaction with the use of the alpha-convention in this case. The latest of these is perhaps Stampe's (1972).

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Baby Talk in Greek[1]

Gaberell Drachman

1. Introduction.

Baby talk may be broadly defined as that form of speech, culture for culture, considered appropriate in talking to very young children. But adult intuitions as to what is to count as 'appropriate' seem to vary over a very wide spectrum of possibilities, some extreme varieties of which I now consider under appropriate mottos.

1.1. "Treat children as if they were adults learning a second language."

An example of this attitude is the slowed and over-careful pronunciation seen in Hidatsa 'Mother language' (Voegelin, 1954). The blocking of fast and even normal-speed speech processes in such a case is of course important evidence concerning the accessibility, i.e., the psychological reality of those processes.[2]

1.2. "Speak as though you were also a child."

An examination of this extreme interpretation is suggestive in another way: Kelkar's (1964) 'generative protocol' for Marathi baby talk shows us the operation of a codified set of adult intuitions concerning child-language processes of simplification (see Section 2.3 below).

1.3. Formally, I include the possibility converse to the above, viz., "Speak as though the child were in fact a perfectly comprehending adult." So far as content and complexity of sentences is concerned, this is of course impractical: and though many parents (and even perhaps cultures) consciously avoid the use of markedly 'child-like' forms of speech, at least so far as vocabulary items and syntax are concerned, it is also probably the case that every language possesses one or other linguistic mechanism corresponding to the special relation between protector/nurturer and protected/nurturant.

1.4. For Greek, as perhaps for most languages, (Cf. Comanche, in Casagrande 1948; Arabic and Spanish, in Ferguson, 1956, 1964; Gilyak, in Austerlitz 1956), a fourth, and mixed situation in fact obtains--namely the use of (1) suprasegmentals, i.e., special intonations, etc., (2) carressive suffixes (I.b below),

and (3) a special set of lexical items. These last may be utilized either as one-word sentences (the child's only contribution for the earliest stage), or embedded in sentences of the type "Do you want some water?", or "Let's go for a walk" (the parent's code-switching contribution".[3]

I confine myself here to the lexical items themselves,[4] whose semantic content ranges quite narrowly over the terms for kin, parts of the body[5], food, clothing, etc., most crucially including hypocoristics (carressive forms of first names (I.c. below)), and whose sources may be taxonomized (I.d below). However, for exegetical purposes, I shall distinguish between hypocoristics (hereafter, hypo-forms) and the rest (hereafter, bt-forms).

I. Elements of Greek Baby-Talk
   (a) Suprasegmentals
   (b) Hypocoristic suffixes.

      1. -áki; makes non-Human Nouns → Neuter Diminutive/Affective.
         [o kóstas : i kostákis : : o skílos : to skiláki].

      2. -úla; makes Animate Nouns → Feminine Affective.
         [o kóstas : i kostúla : : i ána : i anúla.]

      3. -ítsa; makes Animate Feminine Nouns → Affective.
         [i eléni : i elenítsa].

   (c) Semantic content of Greek Baby-Talk (sporadic occurrences bracketed).

      1. Kin: mummy, daddy. granny, baby, baptizer (brother, sister).
      2. Body: breast/teat, sex organ, backside.
      3. Body-functions: urinate, defecate, sleep, walk, kiss, eat, bite, hurt, hit, pick up (sit, fall, carress, cut, bathe).
      4. Food: food, bread, water, sweet thing, egg, meat.
      5. Clothes: dress, shoes.
      6. Animals: horse, dog, cat, hen, bird (sheep, cow).
      7. Adjectives: hot. all gone (dirty).
      8. Names: hypocoristics [i.e., shortened, and/or suffixed.]
      9. Misc.: car, train, peek-a-boo (toy, doll, fire, bogey, 'bye).

   (d) Taxonomy of Baby-Talk sources.

      1. Forms related to and derivable from a corresponding (fuller) adult form: papá < papútsia 'shoes'; kokó < avγó 'egg'; kokó < γilikó 'sweet'.
      2. Adult forms 'transferred' in meaning (including taboo-replacements: puláki 'female sex organ' (= 'little bird').

3. Forms apparently onomatopoetic, usually reduplicating morphemes: ɣàv-ɣáv 'bow-wow'; tˢi̯ù-tˢi̯ú 'tweet-tweet'.
4. Forms resembling so-called 'international' bt-words, usually reduplicating syllables: mamá 'mammy'; babás 'daddy'.
5. Forms representing loans,[6] often widely diffused: náni 'sleep'; bwa 'drink'; pápa 'bread'.
6. Other forms of unknown source: tˢísa 'urinate'; dᶻiz 'hot'; mákia 'kiss'.

It is with the phonological analysis of the whole set of lexical items that this paper is mainly concerned. Using Greek data,[7] I shall attempt in a principled way to disentangle three elements involved in the transmission of baby-talk words from generation to generation: namely (1) 'blurred childhood memory'--that is, intuitions about child language somehow surviving in the adult; (2) 'Substrate' pressure, i.e., the influence of the adult's language; and, (3) Stereotyped and culture-given adult notions about children's language capabilities.

2. Phonological-Strata in bt forms.

2.1. Blurred childhood memory.

2.1.1. Putative universals of bt-shapes.

In "Why mamma and papa?", Jakobson (1960) outlined some typological predictions concerning the shape of baby-talk words. Let me survey the Greek forms from his criteria, which constitute my five 'universals of baby-talk'. For each universal, I give (only) the exceptions occurring in Greek.

II. (a) CV syllables predominate--
but Standard (St.) Greek also has: am 'eat'; mam 'bread'; áta 'walk'; ópa 'pick up'; babás 'daddy'. Cypriot has: áɣa 'granny'; uv·á 'pain'; áɣ·u 'carress'.

(b) Clusters absent--
but St. Greek also has: stráta 'walk'; psìpsí 'cat'; plìtˢ-plátˢ 'bathe'. Cypriot has: steté 'granny'; brúa 'water'.

(c) All CVCV are sequences of identical syllables--
but St. Greek also has: bébis/béba 'baby'; náni 'sleep'; tˢísa 'urinate'. Arta has: vávu 'granny'.

(d) Labial and dental stops and nasals dominate--
but St. Greek also has:
(1) kaká 'defecation'; kokó 'sweet thing'; kaká 'hen cackling'; mákia 'kiss'; nanákia 'sleep'.

(2) t^{s}ísa 'urinate'; $t^{s}it^{s}$í 'meat'; d^{z}iz 'hot';
(3) vavá 'hurt'; γàv-γáv 'dog'
and Cypriot also has: čil·ín 'tummy'; piš·á 'urine'; píči-píči 'bath'; túču 'sit'; kíxi 'cut'; áγ·u 'carress'; ax·á 'dirty'; úf·u 'food'.

(e) Vowels assimilate to preceding consonants (Labial/Velar consonants take back vowels, Dental/Palatal consonants take front vowels)--
but St. Greek also has:
bébis 'baby'; memé 'breast'; nonós 'baptizer'; pipí 'dress'; (be)bé 'sheep'; and d^{z}a 'peek-a-boo'.
Cypriot also has: túču 'sit'; učá 'peek-a-boo'; kíxi 'cut'; píči-píči 'bath'; uš·í 'horse'.

2.1.2. Explanatory-theory--from variants.

Now it might be insisted that Jakobson was concerned with statistical dominance rather than absolute universality. Still, the fair number of exceptions to his dicta which the data presents were perhaps better explained than dismissed as a statistical minority.

An attempt at an explanation might well begin with the examination of the forms for which there are variants within even single idiolects, and in particular those variants which are apparently related by something I will call 'degree of complexity'. III gives these latter forms, where 'degree of complexity' is assumed to correspond to the notion that one (on the right) may be derived from the other (on the left).

III. 'Derived' variants.

(a)	papút^{s}ia	→	papá			'shoes'
	γlikó	→	kokó			'sweet'
	avγó	→	kokó			'egg'
(b)	stráta	→	táta	→	áta	'walk'
	dedéni	→	déni	→	de	'horse'
	pápala	→	pápa	→	pa	'all gone'
	nanákia	→	náni			'sleep'
	mákia	→	ma			'kiss'
(c)	dadá	? →	da			'hit'
	vavá	? →	va			'pain'
	γàv-γáv	? →	wau			'dog'

Under a, 'shoes' shows syllable loss, while 'sweet' and 'egg' show cluster reduction and consonant harmony and reduplication respectively. Under b, a steady attrition of unstressed syllables is seen.[8] The forms under c might (though I doubt it) have to do with replication of an original monosyllable [Cf. data in Roussey (1899) for French] rather than an original disyllable. Wau 'bow-wow',

finally, may be a separate etymon from γὰν-γάν.

2.1.3. Extension to all bt-forms.

The fact that child language processes apparently connect these forms suggests that the shorter forms result from the operation of processes on the longer ones, and are thus to be looked upon as filter-products of the latter. We may then attempt to extend this notion to bt-forms in general, by assuming a source [X] for any form of unknown origin and asking, of the output shape, what filter processes might have operated to produce it from [X].

IV shows the types of filter process involved:

IV. 1. Losses of unstressed syllables.
2. Consonant degradation--a matter of strength and place: a 'strong' consonant is preferred, Lab/Dent articulations are preferred.
3. Vowel strength: sonorance and color are preferred.
4. Clusters: the stronger of two consonant types is preferred, the weaker being assimilated or eliminated.[9]
5. Trans-syllabic assimilations (inertial or anticipatory), give vowel or consonant harmony.

In V below I give, as Stage I (reading from the left of the chart) the results of the operation of the full train of filter processes, describing in the second column the surface shapes allowed. In the following stages (reading down the chart), I describe the successive limitations and blocking of processes, again in terms of the outputs they permit. Thus I have distributed the Greek bt-forms as though they were the outputs for a fairly small number of successive stages (roughly as in I-IV) in the maturation of the child's systematic pronunciation ability. It will be noticed that the unusual question implicit here is: "At what <u>stage</u> (not to be equated with age) can a given form be pronounced, taking account of its <u>total</u> make up, rather than dealing with segments individually?". It is I think a question relevant for language-development stages (as here) when distant-assimilation processes are still common, and often bleed regular substitution processes, as I shall illustrate (2.1.4. below).

V. Bt-forms as supposed outputs of 'process-filters'.

Stage	Developments	Athenian
I	CV (C_IV_I) C= Stop, N. V= [a], or allophonic to Lab. or Dent.	ma, ba, pa, ta, d^za, da, de mamá, papá, popó, pápa dedé, $d^zid^zí$, niní, dadá tatá.
II	VC(V), CV(N), CVCVC V_2 may break harmony. Final s/n.[10]	am, mam, ham kaká, kukú, kokó, pipí, bebé~be, memé, tutú, náni, mána, babás, papús, monós, bébis~béba, d^ziz, yayá, áta, ópa.
III	Spirants in all positions C_2 may break harmony simple trisyllabics	fu, va~vavá, t^sisa, ɣàv-ɣáv puláki, pápala, mákia. dedéni, nanákia.
IV	Some initial clusters	blùm-blúm, plìt^s-plát^s, psì-psí, stráta

2.1.4. Application to hypocoristics.

The semi-abstract appearance of this analysis of bt-forms seems fairly justified when we turn to the shapes of hypo-forms, which are found to correspond to an analogous sequence of developmental stages (VI below).

But instead of the meagre number of bt-variants, we now face a remarkable abundance of hypo-variants. This is partly due to the fact that the full forms of Greek names are mostly polysyllabic [a sample of some 70 names I used, one tenth = disyllabic, one fifth tri-syllabic, leaving seventy-percent tetrasyllabic], so that the more 'stages' are involved for each name. But it is also due to fairly free stress-shifts,[11] each shift of course affecting the vulnerability of particular syllables and segments to degradation and loss.

For present purposes, compare simply No. 4--ðímos vs. mítsos, for ðimítrios; No. 10 pérso vs. fóni for persefóni. VI shows some of the variants for eleven sample forms, stage by stage as before. For typical degradation processes consider:

1. syll losses--No. 1 - afroðíti--títi
2. For stops from spirants--No. 3 - ɣóryos--dódos
3. Clusters--No. i.--ðéspina, dépo; 4. dimítrios, mít^{s}os.

Most interesting, perhaps, is the intervention of a vowel and consonant harmony, bleeding normal degradation processes. Observe these processes, e.g., in No. 1 afroðíti gives fríðo: the derivation must be afroðíti - afriðíti by harmony then stress shift (afríðiti); only then may syllable loss and suffix switch occur! For the consonants, consider No. 4 ðimítrios. If stress shift occurs we ought to get ðímis for an early stage: but at such a stage the initial delta is weak, and medial m is not achievable except after vowels, h, or another nasal: both problems are solved by nasal harmony, giving mímis.

VI. Hypocoristic forms as supposed outputs of 'process-filters'.

	Stage I	Stage II	Stage III	Stage IV	Adult form
1	títi	díti	fífi, ðíti	afró, fríti, afríti, fríðo	afroðíti
2	níni	tóto	éfi, fofó	fróso, frosíni	efrosíni
3		dódos, lólos, gógos	ɣátˢis, ɣóɣos ɣóliˆos	ýóris	ýóɣos
4		mímis, tákis	ðímos, mítˢos mítlis		ðimítrios
5		téti, néno, ténis	ðímos	sténis, mosténis	ðimosθénis
6		kókos, níno	kótiˆas, dínos	kósta, kandís, kotandís	kostandínos
7		táti, nóta, dóta nótis, pána, pános	ɣótu, panáɣos		panaýótis
8		pipína, pípi, pépi, dépi, yépo	ðépo, ðéspo	zéspina, péspina	ðéspina
9		nína, tína, lína, niníka	katína	terína, rína, rinúla	katerína
10		nóni	fofó, fóni sifón'	pérsa, persón'	persefóni
11			viví, tˢeví palása, siˆoví	paráskis, skeví	paraskeví

The distribution of forms over the above stages supports the notion that both bt- and hypo-shapes correspond to (overlapping) ranges of stages in child language acquisition rather than to the single (and

very early) stage that Jakobson's criteria seem to define. I have thus not only explained why there are so many exceptions to those criteria, but have also given some substance to the notion 'blurred child-language memory in adults.'

2.2. "Substratum" influence.

If it were the case that bt-forms showed only the influence of child language processes, then they would probably be of the same difficulty the world over, insofar as their shapes everywhere seem to reflect very early processes. They should show very great similarity of form, and thus of degree of 'difficulty'.

In this light, consider the bt-forms for two dialects of Greek quite different from Athenian--those of Cyprus and Arcarnania.

2.2.1. Cypriot.

So far as Cypriot is concerned (VII below) there seems to be more difficulty than for St. Greek. The forms cluster strongly over stages II-III as against I-II for St. Greek (cf. V). This shift is in part attributable to the trend to closed syllables, both final and (by gemination) medially, and in part to the occurrence of palatal consonants. But these three features are in fact characteristics of the adult dialect of Cyprus and distinguish it from St. Greek.

It thus appears that some of the content and shape of bt-forms must be attributed to the influence of the adult language substratum. This substratum, I suggest, in fact controls what I will call the "threshold" of the filter-function which I characterized (with Kelkar) as 'blurred childhood memory'. The threshold varies from dialect to dialect, as I have shown for Greek, and even more obviously from language to language [e.g. where Athenian bt-forms sweep the stages I-II and Cypriot the stages II-III, the Gilyak forms (Austerlitz 1956) seem to cover stages III-IV.] This reflects the fact that adult intuitions of 'ease of pronunciation' are grounded in the complexity of the substratum.[12]

VII. Bt-forms as supposed outputs of 'process-filters'.

Stage	Developments	Cypriot
I	CV (C_IV_I) C= Stop, N. V= [a], or allophonic to Lab. or Dent.	m.a., mám·a, mam·á-mám·a, niní, tét·e.
II	VC(V), CV(N), CVCVC V_2 may break harmony. Final s/n.	kaká, kaká-kak·á, kok·ó, kau̯, be, púa, náni, papú, papás, tatás, pop·ón, $t^{s}it^{s}$·ín, ɛ́ɣa-aɣá, áta-át·a, óp·a, ám·u, ám·a.
III	Spirants in all positions. C_2 may break harmony. Simple trisyllabics	fu, úf·u-uf·ú, uv·á, vau̯, ɣalín, put^{s}·ín, pis·ín mis·ín, ax·á, ax·á, piš·á, uš·í, učá, pǐči-píči, pul·ín, pul·ú, páp·al·a, papal·ís, min·á, mákia, óp·ala, kol·ín.
IV	Some initial clusters	brúa, steté, stráta.

2.2.2. Acarnanian.

For my second example (see VIII below) I take the stressing of bt-forms. In Greek, stress alternations are common, the two most important causes being the trisyllabic rule and the stress-attraction rule.

(1) Tri-syllabic rule: simply put, stress may not (for most dialects) lie further back than the third syllable from the end of the phonological word. Thus Nom. Sg. 'name' = ónoma but Nom. Pl. (as in 'I gave the name') ta onómata (and not ta ónomata).

(2) Stress-attraction: certain suffixes such as Genitive sing. -u behave as stress-attractants--o ánθropos, tu anθrópu ('the men, of the men').

A threefold situation has evolved in this respect. At the one extreme, the adjective has everywhere in Greek adopted rizotonic stress, which may contradict the stress-attraction rule.[13] At the other extreme stands the verb, which for a few dialects has adopted rizotonic stress. Importantly, Acarnanian is among these: we find for St. Greek érxome: erxómaste 'I'm coming, we're coming', cf. Acarnanian érxome: érxomaste.

But the noun stands between: to different degrees, both dialects and idiolects begin to show stress leveling here too, so that we find beside Acc. Pl. tus anthrópus, also (optional) tus ánthropus.

It is thus of interest that in Acarnanian, with obligatory rizotonic stress for both the Adjective and the verb, all the disyllabic bt-forms (though not the hypo-forms) are stressed on the first syllable. It is as though they were interpreted as containing a stem to be stressed (the first syllable), and a suffix (the second syllable): and in fact they strongly resemble disyllabic imperatives (cf. Cypriot ax·á: áx'a, fn. 3).

Stress retraction (and stabilization?) thus seems under the influence of the dialect, just as the overall 'threshold of difficulty' proved to be. It may be that bt-forms, as a marginal system within language, are especially sensitive to the trend of the adult language. In such an interpretation, they here constitute an 'advance guard' Noun sub-system showing stress leveling by retraction.[14]

VIII. Acarnanian stress-shift (relevant variants only, for Athens).

Gloss	Athens	Acarn.	Gloss	Athens	Acarn.
mummy	mána	mána	horse	dedé	dédi
daddy	babás	tátas	pick up	ópa	ápa
granny	yayá	váva	egg	kokó	kóko
baby	béba~bébis	bébe	sweet	kokó	kóko
sister	aδelfí	yáya	defecate	kaká	káka
brother	aδelfós	lólos	shoes	papá	pápa
meat	c^{s}it^{s}í	t^{s}ít^{s}i	sheep	bebé	bébe

2.3. Adult conventions.

Not only 'blurred childhood memory' and substratum, but also conventionalized mock-child processes may influence baby-talk. The most interesting case, is that of the Marathi Baby Talk (MBT),[15] already referred to above.

Now it is perfectly reasonable to hold that most of the 'processes' codified by Kelkar resemble typical sound changes as described in historical linguistics, and (more to the present point) that they also resemble child language processes. There are processes describable as constraining the vowel-system; simplification of consonant-types (e.g., partial elimination of

the retroflex consonants); cluster-reduction; and even a solitary rule assimilating a lateral to a later nasal in the same word.

But there are aspects of MBT that do not remind one of child language at all. A few examples must suffice. First, there are some wierd hierarchies, e.g., while /k/ becomes more child-like (as /t/) unconditionally, /v/ becomes a stop only before /y/ or /i/; second, vowel-length is lost unconditionally at the first degree of Marathi babyishness; whereas in normal acquisition, length-distinctions are made quite early, e.g., by 24 months for one study of Norwegian (Vanvik 1971)[16]; third, the rich variety of consonant and vowel harmony processes that normally takes a child into his fourth year and beyond, is here represented by a single process (the nasal-harmony I mentioned). Lastly, surely no self-respecting child still substituting dentals for velars would hesitate to drop the occasional unstressed vowel--yet no suggestion of syllable loss occurs in the Marathi description.[17]

I conclude that, though perhaps quite systematic in its way, MBT must be characterized as non-authentic child language at a variety of apparently quite arbitrary points.

3. Conclusions.

3.1. The 'success' and dangers of baby-talk.

If we look upon Baby-talk as a kind of Pidgin language, we are tempted to ask two questions: how 'successful' is the particular Pidgin, language by language; and, conversely, how far is the charge justified that the child's language development may actually be retarded by teaching him the Pidgin in the first place?

For both questions, the answer must take account of the type of Pidgin. First consider the languages exemplified by Greek, where Pidginization extends only to lexical items, and even then only covers some fifty terms. It is not difficult to compare the difficulty of bt-forms with the corresponding adult forms. By simply extending the grid of developmental stages already discussed (section 2.1.3 above), we may assign the adult forms as follows:

Stage I: No forms.
Stage II: possibly kei̯, pai̯ (ignoring the forms for granny, baptizer, and peek-a-boo, which are identical with the bt-forms).
Stage III: poná, kóta, filí, síko, ɣáta, xézo, vizí, peóí, kimáme, pisinó.
Stage IV: moró, neró, tróɣo, tréno, kréas, stíθos, psomí, xtipó, ɣlikó, skílo, svíno, avɣó, kúkla, áloɣo.
Stave V: ɣavýizo, peɣníði, patéras, faɣitó, próvato, kókoras, katuró, foréma, ɣái̯ðaros, mitéra.
Stage VI: perípato, nanurízo, akáθarto, papúts̯ia, aýeláða, telíose, aftokínito.

In that the bulk of the corresponding adult forms clearly represent later stages in the child's articulatory maturity, the bt-forms may be said to be successful, and this is presumably true for the lexical part of baby-talk generally. It is also reasonable to assert that the (numerically) slight burden on memory represented by this vocabulary having to be re-learned later hardly takes away from its useful function for very young children.

On the other hand, more extreme versions of pidginization, such as Marathi Baby-talk, might be expected to present a more serious problem to the child at a later stage.[18] MBT, with its consistent but arbitrary 'mergers' (Cf. the question of vowel-length mentioned above) puts the child in the position of (say) a speaker of early Slavic trying to master the cognate vocabulary of an (for him contemporary) Indic language, for which he must learn (e.g.) which of his initial /b/'s correspond to /b/, and which to /b^h/.

3.2. The survival of child-language processes.

If it is granted that the transmission of baby-talk depends partly on adult intuitions concerning child-language processes, it is tempting to seek other kinds of evidence for this beyond early childhood. In children, a fertile field of investigation might be the question of language-regression, as found in psychotic regression or (less drastically perhaps) in stuttering; compare remarks on psychosis among the Pilaga Indians in Henry and Henry (1940), and on speech defects in Stinchfield and Young (1938).

Though the methodological problems are formidable, it is also worthwhile to try to tap adult intuitions concerning child processes directly, by asking them to say words 'as if you were talking to a baby', as in the (forthcoming) work of Schourup.

3.3. Adult conventions.

The difficult problem of distinguishing between child and adult processes is perhaps to be illuminated by (e.g.) comparing child abbreviation in hypocoristics (Cf. Hoffman 1969, Drachman forthcoming) with those of adults in advertising, laboratory jargon, etc. The conventions for drunken speech, conventions for speaking like a foreigner or dialect speaker, etc., would also no doubt repay study, as would those employed in 'instant Pidgin'--i.e., making oneself understood to a near-monolingual foreigner.

Footnotes

1. This paper is a slightly expanded version of that read at the Christmas 1972 meeting of the Linguistic Society of America in Atlanta. It grew out of current research on the acquisition of Greek as a native language, work which was partly supported by Grants-in-Aid (summers of 1971 and 1972) and by the award of a Research Quarter for Autumn 1972 by the College of Humanities, The Ohio State University.

2. Caution is required, for it is also true of 'Mother language' that (e.g.) stress distinctions are often wiped out, and that occasional loss of sequences, possible loss of fortis-lenis contrast, etc., occur.

3. For Greek, the only syntactically interesting facts are the existence of (1) an occasional adult verb, e.g., kakaróno 'to die' (from kaká, 'defecate'?), and (2) rare cases of stress retraction to distinguish the imperative, as in Cypriot ax·á 'dirty' vs. áx·a 'throw it away!' (cf. 2.2.2. below). Compare the possibility of inflection in Comanche (Casagrande 1948)--but this is for use with older children.

4. Additions arise sporadically within individual families, either from the child's assignment of an (apparently) arbitrary phonetic shape to denote some more or less broad semantic field, or by adoption of a child degradation of an adult form.

5. The sizes of the sub-classes varies from language to language. That for body-parts, for instance, contains 3 items for Greek but 13 for Gilyak--perhaps reflecting varying ranges of taboo.

6. The question of accidental resemblance is a serious one for bt-forms. Not only is the number of possible shapes most constrained, as will be seen (sections 2.1.2-3 below), but the range of ideas to be expressed is extremely small. As a result, the possibility of chance shape-resemblances for the same meaning is correspondingly high. For example:

(i) Greek-Comanche: Greek niní: Comanche niní 'baby'; Gk. kokó: Com. kokó? 'sweet thing'; Gk. (Cypriot) ax·á: Com. ?ax 'dirty'; Gk. dᶻidᶻí: Com. cicí 'breast'. (Cf. Casagrande 1948).

(ii) Greek-Gilyak: Gk. niní: Gil. nene 'baby'; Gk. tˢísa: Gil. šisa 'urinate'; Gk. ópa: Gil. (b)upa 'carry'. (Cf. Austerlitz 1956).

On the other hand, the very large proportion of forms in common between Greek and Arabic is suggestive of diffusion, as Ferguson has pointed out. I list the 14 Greek (including Cypriot) forms that are relevant (Cf. Ferguson 1956): bébis 'baby', mam-ma 'food', bwa-búa 'water', náni 'sleep', kaká 'defecate', dadá 'hit', vavá 'hurt', dᶻidᶻí 'breast', mamá 'mother', babás 'father', γàv-γáv 'dog', pisín 'cat', tutú 'vehicle', steté 'granny'.

7. The baby-talk forms were elicited from St. Greek and dialect speakers in Athens. Among the latter, special thanks are due to Mr. Panayotis Kontos for the Acarnanian forms. The hypocoristic forms were taken from the collection in Boutouras (1912).

8. Náni shows 'allophony' whereby the unstressed front vowel corresponds to the dental consonant [n]: this is the underlying shape--the suffix -áki always replaces a final vowel, cf. ɣéri - ɣeráki - ɣeráki̯a 'hand, little hand, little hands'; and thus náni - naráki - naráki̯a 'sleep'.

9. These processes may be bled by processes destroying clusters, such as syllabification (if a resonant is present as one member) or vowel-epenthesis.

10. It will be interesting to see, from projected child-language studies, how the acquisition of final consonants is keyed to the production of case-endings, for languages (like Greek) with so-called 'free word order'. While -s belongs to Nominative singular and plural, and -n to Accusative singular and Genitive plural in the standard language, Cypriot requires -n for Nom. Sg. also.

11. Even secondary stress shift is involved: Cf. melpoméni - mélpo, but also melpó. For a full treatment of such stress-shifts, see my "Greek Hypocoristics" (in preparation).

12. Note the aspects of baby-talk shapes that in fact contradict the adult substratum: in particular, the presence of (1) 'rare' segments, and (2) 'marginal' sounds.

(1) The adult native speaker's feeling of what is 'difficult' is of course partly conditioned by frequency of occurrence, which helps to explain the frequent presence of velars in bt-forms for both Arabic and Gilyak.

The opposed psychological attitude, that what is exotic or unusual is more suitably 'affective' (Cf. Jakobson's 'the expressive value of the extraordinary', 1968, 26) might in turn relate to the use of labial emphatics in Arabic bt-forms, against the frequency criterion. Such a view applies also to the Twana use of Puget Sound loan words containing (non-Twana) g^w and d^z in the bt-forms (e.g.) for 'navel, bogey-man' respectively (Drachman 1969), as also perhaps to the 'survival' of [pbm] in Iroquoian baby talk (Chamberlain 1890), and the survival of proto-Salish [l] in Nootka bt-forms (Sapir

In the same vein, Salish forms containing the segments m, k/k' might have survived the sound shift giving b, č/č' respectively, in words considered affective such as the bt-forms in Twana for

(a) daddy, defecate, backside, thin, few--for Salish [m] (Cf. also /m/ in Quileute (Frachtenberg 1920)
(b) urinate, mummy, granny, spank, small--for Salish [k/k'].

For Greek, the solitary form [be·] 'sheep' is of interest as a putative historical survival, since from approximately the time of Koine (4th century BC) stops because spirants and we would expect #[ve·]. It would be interesting to hold that the apparent survival

simply reflects the tenacity of child-language processes, but that the (admittedly, much later borrowed) form [vavá] 'pain' did not revert to *[babá] by the same process.

(2) The so-called Mediterranean word for 'water' (Ferguson 1964; cf. Heraeus (1904)) has the shape [m*] (a bilabial trill). Against the onomatopoetic view concerning such child forms, I believe this example to constitute a concession to very early childhood: I have watched several babies of some 12 months crying with just such a sound.

Similarly there are violations of Greek phonotactics in some bt-forms. While there are (see Kourmoulis, 1967) no native noun forms in final [-é], we find it in bt-forms as bebé 'sheep' memé 'breast', dedé 'horse'; likewise, while there is only one native noun in final [-ú] (alepú 'wolf'), it occurs in the bt-forms pul·ú 'sex organ', uf·ú 'food', fú 'fire', tutú 'motor car'. But it is interesting to compare the 'affective' attitude towards final [-ú] even in the adult language, which has forms like γlosú 'long tongue', kamomatú 'coquette'. There are also bt-forms with final consonants 'forbidden' in the native vocabulary, as mam 'eat', blùm-blúm 'bath', γàv-γáv 'bow-wow'.

13. Thus o ánθropos: Gen. sg. tu anθrópu 'of the man', but o apánθropos: Gen. sg. tu apánθropu (not *apanθrópu) 'of the inhuman one'.

14. Cf. Acarnanian--all 18 disyllabic forms have initial stress; for Athenian - 7 of 30 disyllabic forms have initial stress; for Cypriot - 12 of 38 disyllabic forms have initial stress.

15. Cf. the many and various secret languages invented by children.

16. Cf. the data for the acquisition of differential vowel-length in English, in Velten (1943) and Naeser (1970).

17. It is hard, especially in the absence of relevant data in Kelkar's paper, to concede that (p. 50, fn. 8) no items occur which are child-speech but not baby-talk.

18. The status of the over-careful speech of Hidatsa Mother language in this respect is more difficult to assess. Cf. Voegelin's strictures.

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A Cross-Language Study of Vowel Nasalization[1]

Lawrence C. Schourup

0. Introduction

The study of nasalization crucially involves nasal consonants, both because it appears, as Ferguson (1963: 59) has claimed, that, borrowing and analogy aside, constrastively nasalized vowels almost always[2] arise through loss of a nasal consonant, and because of the structure of the nasal consonant itself of which one striking feature is the independence of oral closure and nasality. This double structure has lead Drachman (1969: 202), Foley (196?: 21) and others to view nasals as nasally released stops; but the uniqueness of the nasal consonant rests primarily in the fact that the nasality component can represent the entire segment without accompanying oral closure in the phonetic representation. It is assumed below that several nasalization phenomena can be correctly viewed as the extension, contraction, or migration of the velic opening and/or oral closure components of nasals. Five aspects of nasalization are examined separately with a view to determining their cross-language characteristics, and the tentative universals that emerge from this comparative work are for the most part accounted for by referring to physiological pressures and constraints.

1. The environment for regressive nasalization

Below are listed several languages claimed to exhibit regressive nasalization of vowels before nasal consonants:

1. Amoy* (Chu 1970: 144) __N#
2. Hausa (Hodge 1947: 10) __N#
3. Tillamook (Thompson (1966: 314) __N$ ($=syllable)
4. Germanic* (Moore and Knott 1955) __Nx (x=velar fricative)
5. Polish* (Lightner 1963: 225) __N#, __N [+cont] (+cont= fricative, nasal, or liquid)
6. Old English* (Moore and Knott 1955) __N $\begin{bmatrix} +\text{cont} \\ +\text{obst} \end{bmatrix}$

7.	Lithuanian* (Kenstowicz 1969)	__N# __N [+cont] (+cont=j, v, l, r, m, n, s, z, š, ž)
8.	Ịjọ (Williamson 1965: 16-7)	__N# __NC
9.	Fanti (Welmers 1946: 16)	__N# __NC
10.	French* (Morin 1972: 102; cf. Schane 1968: 48 and Lightner 1970: 193)	__N#
11.	Old Church Slavonic* (Lightner 1970: 182)	__N# __NC (C≠j)
12.	Hindi-Urdu (Narang and Becker 1971: 653-4)	__N# __NC
13.	Korean (Jung (1962: 13-20)	__N# (i, u) __N (e, o)
14.	Navaho (Sapir and Hoijer 1967: 11)	__n, n̩ (̩=syllabic)
15.	Ayutla Mixtec (Pankratz and Pike (1967: 289)	__N
16.	Portuguese (Saciuk 1970: 198)	__N
17.	Old Norse* (Gordon 1957: 267)	__N
18.	Keresan (Spencer 1946: 235)	__N

This list provides a basis for the following generalizations:

(1) In no language considered do non-continuants after nasals permit nasalization when continuants do not also do so. Moreover, there are four languages in which continuants, but not non-continuants, permit nasalization.

(2) Environments which include # are highly favored among these languages. In some--Amoy, Korean (i, u), Hausa--nasalization occurs only word-finally. The two languages claimed to nasalize vowels in other environments, but not word-finally, are known only from written records (Old English and Germanic) and are therefore highly questionable sources for information about a subtle feature like nasality.

In Keresan (Spencer 1946: 235) vowels are nasalized before nasals regardless of the following environment, but nasalization is most apparent before word-final nasals.

(3) In no language examined are vowels nasalized before prevocalic nasals when they are not also nasalized before all

preconsonantal and word-final nasals.

Turning now to the characteristics of the vowel that undergoes nasalization, more generalizations are possible:

(4) Low vowels are more likely to be regressively nasalized than high ones. Lightner (1970: 214-5) quotes Delattre (unpub. paper) as saying that in French a was nasalized first historically, followed by mid and then high vowels. A similar tendency is observed in Korean where nasalization of mid vowels occurs before all nasals, but nasalization of high vowels occurs only before word-final nasals. In Thai (Noss 1964: 15) only low vowels are nasalized progressively. In Kashubian (Shevelov 1965) ę is raised in some environments to ɪ̨ and lowered in others to ą; when ę is raised to ɪ̨, nasalization is lost, but it is retained when ę is lowered. In no language considered are high vowels regressively nasalized while low ones are not. Harrington (1946) and Moll (1962) have suggested that low vowels nasalize more readily because the palatoglossus muscles which connect the velum with the tongue musculature tend to draw the velum down when the tongue is lowered for a low vowel.

(5) There is also a tendency for back vowels to nasalize more readily than front ones. In Island Carib (Taylor 1951: 231) a, o and u are nasalized word-finally after a nasal, but i and e remain oral. In Ịjọ (Williamson 1965: 17) back vowels are more nasalized than front ones, with i: (cf. (4) immediately above) least nasalized of all. In Sora and other Munda languages (Stampe, personal communication) only back vowels are progressively nasalized; front and central vowels are unaffected.

(6) Stress and nasalization are strongly correlated. In Irish (O'rahilly 1932: 194) only stressed naasalized vowels undergo shifts attributable to nasality. In Portuguese (Saciuk 1970: 209) a denasalization rule affecting the first member of vowel sequences affects that vowel only if it is unstressed. In Panama Spanish (Robe 1960: 36) progressive nasalization is claimed to affect only stressed vowels. In the Darmstadt dialect of German (Keller 1961: 166) nasalized vowels have arisen only where stressed oral vowels preceded final nasals. In the Upper Austrian dialect of German (Keller 1961: 207) all vowels are nasalized before nasals, but nasalization is often lacking when the vowels in question are in unstressed position in the sentence. In Goajiro (Holmer 1950: 50) "every syllable containing a medial nasalized vowel...has main stress." In Cashibo (Shell 1950: 199) only when a contrastively nasalized vowel is stressed does nasalization spread from that vowel to a following one. In Breton (Dressler 1972: 21) unstressed final vowels are denasalized in fast speech. In early Icelandic (Gordon 1957: 267) nasalization was lost first in unaccented syllables. In Island Carib (Taylor 1951: 232-3) "nasalization is usually stronger with stressed than with unstressed syllables." And, in the Hopkins dialect of the same language, "in every case where a shift of nasalization occurs, it is accompanied by a parallel shifting of stress." The following forms show the concurrent shift of stress and

nasalization:

ida lĩ́a sa	'how is it (that...)?'
má-buga nĩ́a	'didn't I tell thee?'
ĩ́o	'hymen'
tĩ́o	'her hymen'
uĩ́-bai	'whistle it!'
uáiriti lĩ́a	'great-is-it his-anger'

versus:

ida liã́-gi	'how is he?'
aríha niã́-dibu	'mind lest I see thee'
gaiṍgiru	'she's still a virgin'
maiṍharu	'she's no longer a virgin'
tĩ́uira	'she whistle(s, d)'
gã́iaha uogóri lèa	'this man got angry'

Consider also:

/gáiu+ẽ/ --- gã́ie	'eggs'

(See also Taylor (195 : 233) for details of a similar alternation.) Finally, in the same dialect, a "word-final unstressed vowel usually becomes oral when the word takes a suffix."

In no language examined is there attested nasalization of unstressed vowels to the exclusion of stressed vowels.

The problem which now arises is what to make of these results. If the data are representative, we might be justified in proposing a universal rule of roughly the following form:

$$\begin{bmatrix} V \\ !stress \\ !back \\ !low \end{bmatrix} \rightarrow [+nasal] \; / \; __N \begin{bmatrix} \# \\ +cont \\ -cont \\ +syll \end{bmatrix}$$

where exclamation points indicate preferred environments and the vertical arrow indicates a strict implicational hierarchy among the post-nasal conditioning factors; thus, if vowels are nasalized before a nasal followed by any element of the hierarchy, then they are also nasalized before all elements listed in the hierarchy above that element.[3]

The position adopted here, however, is that the formula above is an expression of several constraints on regressive nasalization and is not necessarily a universal rule. This reservation seems essential in light of the absence of arguments for the stronger position.[4]

It seems likely that further investigation will provide more detail to the present formulation--for example some specification of which continuants are most likely to permit nasalization before a preceding nasal, and perhaps of which nasals facilitate nasalization, and of finer detail in the ease with which different vowels undergo nasalization.

The reluctance of syllabics to permit nasalization before a preceding nasal can be explained by referring to syllabification. Since languages normally exhibit CV syllables, all that need be said is that a nasal allied to a following syllable (normally the case when a nasal is followed by a vowel) is least likely to nasalize a preceding vowel. Stampe (personal communication) points out the reluctance of nasalization to spread across syllable boundaries in the English words:

zĩ.no 'Zeno' (only slight nasalization of i)
1 3

fĩɪ̃.o 'Finno(-Ugric)' (heavier nasalization of ɪ)

Drachman and Drachman (1971, to appear) note that in Greek voiceless continuants permit vowel nasalization before a preceding nasal more readily than voiceless stops; the following statement, which they offer in explanation, accounts nicely for part of the post-nasal hierarchy detailed above:

> The reason for this seems to be that, since the velum is necessarily raised to satisfy the air-flow (or pressure) condition for the continuant (or stop), it is lowered for the nasal segment prematurely. But if the velum-lowering is sufficiently early, the stop component may well be inhibited altogether; the time alloted to the nasal will be added to the preceding vowel, since that time is required in any case for the velum to rise again for the following consonant.

Drachman's observation coincides with the view expressed earlier, that nasality is the information-bearing component of the nasal.

This explanation is very appealing; indeed, it is difficult to imagine a better one since the requirement which must be met by any theory on this point is that it account for the fact that the vowel is affected by a segment two places to its right. It therefore seems necessary to posit an explanation involving anticipation.

Interestingly, a solution involving pressure and air-flow does not account for the fact that a word boundary is the most likely environment for nasalization. A different principle seems to operate in final position. One possibility emerges if we consider that the range of planning of words is greater than a single segment. In the VNC cases, the velum will act conservatively because it must shut later in the word (a time-consuming operation; see Bjork 1961); that is, it will remain as nearly approximated as it can while still enabling the contrastive function of nasality (of the consonant), but in the case of word-final nasals, the velum need not be prepared for a new ascent and can therefore open early and more completely and remain open longer (cf. Keresan above). This speculation is consistent with an experiment by Moll (1962) in which it was shown that the velum is lowered more when oral vowels are spoken in isolation than when they are flanked by consonants. Unfortunately, the validity of this study is questionable because the corpus consisted of nonsense syllables. More clearly relevant is a study by Bjork (1961) which shows that the velum can be lowered quickly, but must be raised very slowly.

2. Progressive nasalization

Progressive nasalization has been all but ignored in studies of nasalization, but examples of this phenomenon are not scarce. The degree of nasalization can very from slight (English, Portuguese[5]) to heavy (Yoruba, Warao, Sundanese, Navaho, Sora). Below are listed several languages claimed to exhibit progressive nasalization:

1. Ayutla Mixtec (Pankratz and Pike 1967: 289) N__
2. Cora (McMahon 1967: 133) N__
3. Picuris (Trager 1971: 32) N__
4. Sundanese (Robins 1957: 91) N__
5. Yoruba (Ward 1952: 13) N__
6. Central Ewe (Stahlke 1970: 51) N__
7. Land Dayak (Scott 1964: 432) N__
8. Icelandic (Gordon 1957: 267) N__
9. Finnish (Lehiste 1964: 177) N__
10. Fanti (Welmers 1946: 16) N__ (freedom of degree)

11.	Ịjọ (Williamson 1965: 17)	N__ ("somewhat" nasalized)
12.	Navaho (Sapir and Hoijer 1967: 11)	n__ (heavy)
13.	Sora (Stampe, personal communication)	m__ (not n__)
14.	Portuguese (Saciuk 1970: 203)	N__ (minor rule)
15.	Warao (Osborn 1966: 111-2)	N__ #m__#
16.	Eskimo (Thalibitzer 1964: 153)	m, n__# (Optional, effects e only)
17.	Hindi-Urdu (Narang and Becker 1971: 657)	$\left\{\begin{matrix}\#\\+\end{matrix}\right\}$ m__ $\left\{\begin{matrix}\#\\+\end{matrix}\right\}$
18.	Thai (Noss 1964: 15)	N, h, #__

Languages with progressive nasalization do not necessarily inhibit regressive nasalization. Both types are attested for Mundari, Ịjọ, Navaho, Fanti, Portuguese, Icelandic and Thai. Without experimental verification, it is unsafe to speculate about the existence of languages with neither progressive nor regressive nasalization. The same difficulty exists in trying to show that there are languages with only one kind of nasalization, but Lehiste (1964: 177) has shown that there is at least one language, Finnish, in which the only appreciable nasalization is progressive and recently Fant[6] has claimed that nasalization of the following vowel is a necessary condition for the perception of a prevocalic nasal as such.

In at least four of the languages with progressive nasalization (Ayutla Mixtec, Yoruba, Navaho, Ịjọ) the distinction between oral and nasal vowels is neutralized after nasal consonants, but this is not a necessary concomitant of progressive nasalization; in Picuris underlying and surface nasalized vowels contrast on the surface, but there are apparently vowel quality changes which enforce the distinction (Trager 1971: 32).

In Sora (Stampe, personal communication) the hierarchy of vowel heights posited above for regressive nasalization (section 1) is reversed. Back vowels after m are nasalized, but u receives heavy nasalization, o less heavy, and ɔ least of all. Notice that if the velum remains at the same degree of closure, production of a high vowel shunts proportionally more air through the nasal cavities producing heavier nasalization than for a low vowel. It appears, therefore, that two different tendencies for the nasalization of vowels must be recognized: if the velum tends to be held stationary, higher vowels will be

more nasalized than lower ones (so far this has only been observed for progressive nasalization); on the other hand, if the velum bows to anatomical pressures, low vowels will be more nasalized. Since we might expect to find some languages in which both tendencies operate simultaneously, it is not surprising that in Yoruba nasalization (again progressive) is heavy for both high and low vowels, but light for the mid vowels e, ɛ, o, ɔ. This situation can be accounted for by supposing that in Yoruba there is a restriction on the degree to which the velum may be raised in the production of nasal vowels.

3. A constraint on nasalization

In most of the languages considered in this study, nasalization spreads only to vowels adjacent to the nasal (data is not often available concerning diphthongs). But in several languages nasalization spreads into distant syllables:

(1) In Warao (Osborn 1966: 111-2) nasalization initiated by a nasal consonant spreads progressively until it encounters either juncture or a consonant other than the glides w, y, and h.

mõãũ	'give it to him'
nãõ	'come'
inãʷãñã	'summer'
mõʸõ	'comorant'
mẽñõkohi	'shadow'
nãõte	'he will come'
mõãũpu	'give them to him'
mõãũ#ihi	'give it to him, you!'

(2) A strikingly similar phenomenon is observed in Sundanese (Robins 1957: 91). Nasality initiated by the production of a nasal consonant is stopped only by supraglottally articulated consonants, but spreads freely through h and glottal stop.[7]

mãro	'to halve'
ɲĩãr	'to seek'
ɲãĩãn	'to wet'
nĩʔĩs	'to take a holiday'

mĩãsih	'to love'
kumãhã	'how?'
ɲãhõkʏn	'to inform'
bʏŋhãr	'to be rich'

(3) The constraint holds also for regressive nasalization. In the Kolokuma dialect of Ịjọ (Williamson 1965: 16) nasalization spreads regressively from nasals and is stopped only by juncture or consonants other than w, r, and y.

(4) In Tereno (Bendor-Samuel 1966: 350) nasalization is a suprasegmental morpheme denoting forst and second person pronouns. It starts at the beginning of either a verb or noun and spreads as follows: "all the vowels and glides are nasalized up to the first stop or fricative," but nasalization spreads freely through h and glottal stop.

(5) In Ayutla Mixtec (Pankratz and Pike 1967: 289) nasalization spreads progressively through an intervocalic glottal stop:

$$\left\{ \begin{matrix} V \\ VV \\ V?V \end{matrix} \right\} \rightarrow [+\text{nasal}] \quad /N__$$

but is blocked by other consonants.

(6) In Island Carib nasalization shifts with stress, but "nasalization cannot follow stress when the latter moves across consonant boundaries" (Taylor 1951: 233).

sũ	'all, every'
sṹhali	'he has finished'

but

ásura	'to finish'

Similarly:

busuẽ́	'in need/want of'
busẽ́ti	'he wants'

but

abúsera	'to want'

(7) Holmer (1952: 220) remarks that in Seneca "nasalization affects all adjacent vowels and may even extend over a semi-vowel, as in kawenyahsa 'her heart'" = [kãʊ̃ẽ̃...].

(8) In Greenlandic Eskimo (Thalbitzer 1964: 153) nasalization spreads from a nasal to a preceding r, "often even spreading

to the vowel before r."

(9) Stampe (personal communication) reports that in midwestern dialects nasalization spreads through r, l, w, j, i̯, u̯, h, and vowels. It is interesting in connection with what was said in section 1 about the relation between stress and nasalization, that in these dialects nasalization spreads to a syllable with main stress, but not beyond it; thus

ɾ̃āĭm	'rhyme'
fJ̃ūm	'fume'
h̃ɛ̃ĭə̃n	'Helen'
h̃āĭɾ̃ĭŋ	'hollering'
klɛ̃ɾ̃ə̃ts	'Clarence'

but

riw̃āĭɾ̃ĭŋ	'rewiring'.

(10) In Land Dayak (Scott 1964: 435) "prosodic glottal stop, as a junction feature, does not check progressive nasalization...Intervocalic h, j, and w do not in all cases check nasality."

nĭ̃h̃ĭ̃n	'place'
simĭ̃h̃ĭ̃ŋ	'ten'
nãh̃ãn	'bear'
pimãJ̃ĭn	'a game'
pĭJ̃ũm	'kiss'
ŋãJ̃ũn nãJ̃ũn	'swing'
nũw̃ãŋ	'pour'

(In each of these examples there is a supporting nasal in the final syllable which would not, alone, be sufficient to provoke nasalization of an adjacent vowel.)

(11) In Breton (Dressler 1972:16) nasalization may spread regressively through the glide w as in

me:w	'drunk'
mẽ:wĭ	'make drunk'

but not through other consonants.

These facts, along with the absence of languages in which

nasalization spreads through obstruents, suggest the following constraint on nasalization:

> A.0 Nasalization initiated by a nasal segment[8] may never spread through an obstruent.

Gibson (1956: 258) claims that in Pame "nasalization is a suprasegmental phoneme...continuing [from a certain vowel] to the end of the word." If the spread of nasalization in Pame is indeed unrestricted, it represents a counterexample to A.0; but examination of the data given by Gibson in support of his claim fails to turn up a single case of nasalization spreading through an obstruent:

lanhãt	'they will arise'
ŋgolhẽʔɛ̃	'tamale'
nanã̃	'his tongue'
khã́ʔãt	'they put him in office'
mãĭkt	'let's go'
snahõ̃lʔ	'his shirt'
taʔɛ̃́hilʸk	'you sleep (du.)'

Here the only segments that offer no resistance to spreading nasalization are, predictably, glottal stop and h.[9]

Stampe (personal communication) points out that in the midwestern dialects discussed above nasalization sometimes spreads through a fricative, as in

hæ̃zn̩t	'hasn't'

which necessitates reformulation of the constraint to allow nasalization to occasionally spread through lax obstruents. But rather than attempt to adjust the constraint as new and slightly different counterexamples turn up (as they probably will) it seems preferable to formulate the constraint as follows:

> A: Nasalization will not spread from an initiating segment through a segment whose airflow or oral pressure requirements are so high that the velum is forced to close.

This formulation in physiological terms gives a principled explanation of the observed data; it is empirically testable; and it permits variation in the set of segments which may be penetrated by nasalization in particular languages.

4. Vowel quality changes

Often, but by nc means always, the quality of a vowel changes when it becomes nasalized (beyond the change in quality attributable to nasalization itself). Following the data listed below is a composite diagram on which directional tendencies can be seen. Arrows indicate the origin and destination of each change.

Vowel Shifts:

NL=nasalization accompanying nasal loss; oral vowels unchanged
PN=possibly phonemic nasalization; oral vowels unchanged
AN=allophonic nasalization near a nasal
NNA=nasalization not specifically attested, but quality change in the vicinity of nasals only
H=historically; limited to nasal vowels.

1.	Old Norse (Gordon 1957: 275)	ĩ---ẽ	NL
		ũ---õ	NL
2.	French (Schane 1968: 48)	ɛ̃---ã	NL
		ĩ---ɛ̃	NL
		ẽ---ɛ̃	NL
		ỹ---œ̃	NL
		ø̃---œ̃	NL
3.	Hindi (Fairbanks and Misra 1966: xvii)	ẽ---ɛ̃	AN
4.	Irish (O'rahilly 1932: 194)	ẽ---ĩ	AN (stressed vowels only)
5.	Southern Irish (O'rahilly 1932: 195)	ã---õ	AN (stressed vowels only)
		õ---ũ	
6.	Scottish Irish (O'rahilly 1932: 195)	ɔ̃---õ	AN
		æ̃---ẽ	AN
7.	Portuguese (Saciuk 1970: 198)	ã---ã^	AN
		ɛ̃---ẽ	AN
		ɔ̃---õ	AN

8.	Breton (Dressler 1972: 15)	ã---ãˆ	AN
9.	Burmese (Haas 1949: 28-9)	ĩ---ĩ̱	PN
		ã̰---ã	PN
		ũ---ũ̱	PN
10.	Mezquital Otomi (Wallis 1968: 215)	ã---õ̰	PN
11.	Slave (Howard 1963: 42-7)	ð---õ̰	PN
12.	Pame (Gibson 1956: 258)	ũ‹---ð	PN
13.	Yoruba (Ward 1952: 7, 12)	ɔ---õ̰ˆ	PN
		ĩ---ĩˇ	PN
		ũ---ũˇ	PN
		ã---ã›	PN
14.	Slavic (Halle 1963: 295)	e---ɐ	NNA
		o---u	NNA
15.	Hidasta (Halle 1963: 296)	e---i	NNA
		o---ɔ	NNA
16.	Peki (Ewe) (Stahlke 1970: 51)	ð---õ̰	H
		ɛ̃---ɛ̰	H
17.	Siouan (Wolff 1950: 68-71)	ã---ð	H (Osage)
		ũ---ð	H (Osage)
		ũ---ã	H (Omaha-Ponca)
18.	Kashubian (Shevelov 1965: 325)	ɛ̃---ã	H (/__# hard dentals)
		ɛ̃---i	H (elsewhere)
19.	Gujarati (Pandit 1961: 56)	ã---ũ	H
20.	Germanic (Moore and Knott 1955)	ã---ð	H (__N)

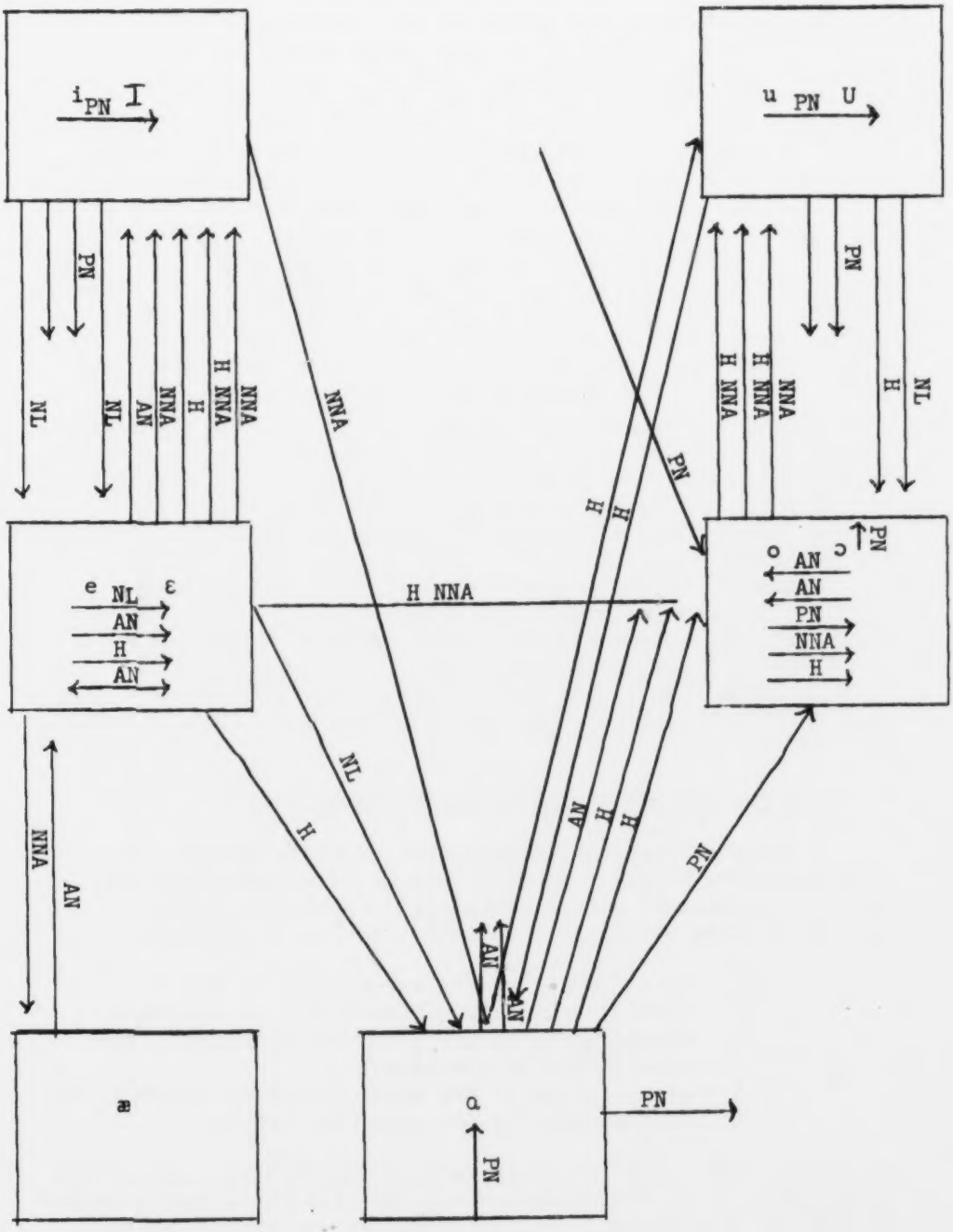
21.	White Tai (Fippinger and Fippinger 1970: 93)	e---i H NNA (/__N)
		o---u H NNA (/__N)
22.	Russian (Lightner 1963: 295)	o---u H NNA (/__NC)
		e---o H NNA (/__NC)
23.	Assiniboine (Levin 1964: 14)	i---a NNA (when i occurs morphophologically /__N)
24.	Southern English (Foley 65)	ɛ---ɪ NNA (/__n)

From the following diagram it is apparent that when vowels become nasalized, they tend to shift back in the mouth rather than forward. The only language in which a nasalized vowel shifts forward is Omaha-Ponca (perhaps not a counterexample, depending on the phonetic quality of a). The explanation for this tendency is not self-evident, but one possibility is that backing of vowels equalizes the volume of the oral and nasal pharynges, as in French (Delattre 1968), causing severe reduction of F_1 and thereby heavy perceived nasality (see section 5 below); thus, we might view vowel backing as a factor contributing to nasalization.

Although it is often claimed that nasalized vowels tend to lower, the diagram shows that this tendency is not very pronounced. There is, however, apparently a tendency for vowels to lower when nasalization is accompanied by nasal loss (French, Old Norse). There is also a marked tendency for vowels to be raised when they are allophonically nasalized adjacent to nasals (Irish, Southern Irish, Scottish Irish, Portuguese, Breton). Vowels with apparent phonemic nasalization do not show clear directional tendencies.

The justification for plotting vowels for which nasalization is not specifically attested on the same diagram as those for which it is attested is that a certain amount of nasalization is inevitable on any prenasal vowel; otherwise the nasal would have to be released by means of velic plosion. (This follows since time must be expended when raising or lowering the velum.)

VOWEL SHIFTS



5. Perceived nasality versus velum lowering

One issue that must be resolved if nasalization is to be better understood is the extent to which perceived nasality is attributable to factors other than velum-lowering. Moll (1962) suggests that the inherent nasalization of æ may not be primarily due to velum lowering, but instead to damping caused by jaw lowering. This conclusion is confirmed by House and Stevens (1956) who point out that even when æ was synthesized without any nasal coupling, it was still perceived as somewhat nasalized. The acoustic correlate which these experiments identified as the cue for nasality is wider bandwidth of the first formant.

In a remarkable study Delattre (1968) has shown that vowel nasalization is produced differently in French and, for example, English or Portuguese; that is, not by velum-lowering alone, but by velum-lowering in conjunction with equalization of the volume of the oral and nasal pharynges. The striking acoustic effect of this (cineradiographically confirmed) articulatory phenomenon is that the first formants of all French nasalized vowels are weak and all at the same frequency. Simple lowering of the velum produces attenuation of F_1, while the 'double' nasalization of French is more marked and characterized not only by attenuation of F_1 but also by virtual anihilation of its harmonics.

Finally, notice that Williamson (1965: 16) claims that in Ịjọ nasalization is perceptually heavier after m than n, but she notes that kymography shows the degree of nasal airflow to be identical for both consonants.

It seems likely that these observations will assume considerable importance when more subtle aspects of nasalization are studied.

6. Relation between nasalization and nasal loss[10]

A process which causes sequences VN to be realized as long nasalized vowels occurs frequently in natural languages, both synchronically and diachornically. Lightner (1970) considers three alternative analyses for this phenomenon:

(1) nasalization of the vowel; loss of the nasal; compensatory lengthening of the vowel.
(2) nasalization of the vowel; lengthening of the vowel; loss of the nasal
(3) nasalization of the vowel; complete assimilation of the nasal to the nasalized vowel.

He argues that the first solution is wrong because compensatory lengthening is an "ill-conceived notion" and cites four examples to justify this claim. He argues against the second solution indirectly by showing that the third solution is preferable.

I will first argue that the first solution cannot be rejected as easily as it is claimed, since the arguments against compensatory

lengthening are insubstantial. Finally, I will suggest that none of the three solutions listed above is entirely correct because all are constrained by unrealistic notational conventions. I will argue in favor of a solution involving migration of articulatory components (cf. Drachman 1969: 202).

6.1. Compensatory lengthening

Lightner cites four examples to show that compensatory lengthening is a mistaken notion and that, therefore, a solution involving compensatory lengthening cannot be correct. In Latin [fagtus] became [fa:xtus] (Lachmann's Law), but [faktus] became [faxtus]. The traditional position is that vowels were lengthened before voiced stops, followed by regressive voicing assimilation in clusters. Foley (ms.), however, has claimed that the process consists rather of weakening of [g] to [x] with corresponding strengthening (compensatory lengthening) of the vowel. But, Lightner points out that Foley's position is untenable because no vowel lengthening accompanies the corresponding lenition of [k] to [x] in Latin. This does not, however, constitute evidence against compensatory lengthening as it has ordinarily been conceived; the traditional circumstance in which compensatory lengthening has been recognized involves the complementary reaction of one segment to the disappearance or change in duration of an adjacent one.

In Japanese /i/ and /u/ can be devoiced in certain environments. Lightner maintains that these voiceless vowels can be optionally deleted, and that if they are, the preceding consonant is lengthened. Since, he claims,[11] clusters arise in Japanese only through the loss of voiceless vowels, we can write

$$V \rightarrow \emptyset \qquad (1)$$

$$C \rightarrow [+long] \,/\, __C \qquad (2)$$

which, however, doesn't directly capture the notion of compensatory lengthening. The rules can capture the appropriate generalization only if their order is reversed and the second assumes global properties; thus:

$$C \rightarrow [+long] \,/\, __V^{*} \qquad (2a) \quad (*=\text{to be deleted})$$

$$V \rightarrow \emptyset \qquad (1)$$

But Lightner rejects these solutions because both appear to involve an unconditioned deletion rule, a type of rule whose existence in natural languages is highly questionable; he chooses instead an analysis in which the vowels totally assimilate to the preceding consonant.

If it is indeed true that any voiceless vowel can be lost in Japanese, we might be able to regard the rule that deletes

vowels as a stronger form of the amply conditioned devoicing rule (Ohso 1971: 22) but this may be unnecessary since Mieko Han (1962: 41) claims to have shown experimentally that Japanese voiceless vowels are not deleted at all: "the time dimension of the vowel phoneme is often taken by the preceding consonant, or period of quasi-silence, but it does not disappear." Her spectrograms show remaining traces of the vowel.

Lightner cites monophthongization as a third piece of evidence against compensatory lengthening. His claim is that the solution involving deletion of one vowel (e.g. ou---ū, eu---ū) followed by compensatory lengthening of the other is counter-intuitive and that cases of monophthongization are fundamentally the same, in his view, as the Japanese example--that is, they involve only assimilation and not deletion.

Finally, Lightner claims that the development from Latin skrīptus to Italian skritto clearly involves complete assimilation rather than deletion of the first stop and compensatory lengthening of the second.

Notice that in the cases of monophthongization and the development of Italian Lightner's claims are not clearly relevant to the discussion since they do not involve assimilation of consonants to vowels. The Japanese example is apparently faulty, and the first Latin example is not relevant at all since it only disqualifies the extension of compensatory lengthening to situations where neither segment loss nor complementary lengthening is involved; thus these examples do not constitute evidence against compensatory lengthening.

6.2. True compensatory phenomena

Before continuing, I will give some arguments in favor of the existence of one kind of compensatory lengthening. In Karok (Bright 1957: 9, 17-8) distinctively short vowels are normally followed by phonetically long consonants. The rule can be stated as follows:

$$C \text{ --- } [-\alpha\text{long}] / \left[\begin{matrix} V \\ \alpha\text{long} \end{matrix}\right] __$$

Here it is impossible to interpret compensatory lengthening as assimilation. One segment reacts to the duration of an adjacent one in such a way that the combined length of the two segments remains relatively constant. Probably the process which assigns phonetic length to consonants following vowels in Karok is similar to syllable structure processes in that it creates maximal contrast between adjacent segments; that is, compensatory lengthening here enhances the contrast between long and short vowels. Roughly the same phenomenon is observed in Italian (Agard and Pietro 1965: 11) where stressed vowels are short before geminate clusters and long before simple consonants. Allen (1962: 56) remarks that in Classical Sanskrit "gemination was automatic after short vowels." Elert (1964) has shown that

in Icelandic, Norwegian, and Swedish there is an inverse relationship between the quantity of a vowel and that of a following consonant.

Strangely, Lightner failed to include in his list of examples any of the kind which have traditionally been regarded as examples of compensatory lengthening. Thus, for example, in Bloomfield (1933: 379-80) we find only examples in which vowels are lengthened in response to consonant loss:[12]

Old English: niht, nixt ---modern Scotch: ni:t

Pre-Latin: dis-lego ---Latin: di:ligo:

Early Latin: cosmis ---Latin: co:mis

P.I.E. *nisdos ---Latin: ni:dus

Gothic: bringan versus Gothic bra:hta (loss of nasal).

Of course, since it is precisely this kind of compensatory lengthening that is at issue in the present case, a genuine argument against the compensatory lengthening solution would have to treat examples like those listed immediately above.

6.3. The assimilation solution

Lightner believes that the development from drink to Old Norse drekka must historically have involved nasalization and lowering of the vowel, followed by assimilation of the nasal to the following stop and denasalization of the vowel; thus

drink---drẽnk---drẽkk---drekk.

He further claims that the development

drink---drẽnk---drẽ:k---drekk

cannot be seriously considered in the absence of independent evidence for vowel lengthening. It is not clear why this example is thought to constitute evidence for the assimilation treatment of the VN---$\bar{V}$: examples. At most it might be taken as evidence for complete assimilation of nasals to following stops.

Lightner cites Gordon's claim (1957: 267) that Old Norse had geminate stops in words like drekka, but there is some reason to doubt that Old Norse ever really had double consonants. In modern Icelandic (Einarsson 1949) orthographic geminate stops are phonetically 'preaspirated'; thus drekka is now [drehka] and what has apparently taken place is incomplete assimilation of the nasal to the following stop

(loss of nasality, voicing and point of articulation). This is not an implausible development, since a synchronic rule of Menomini (Bloomfield 1939: 113) has precisely the same effect (n → h/__C) and a similar rule is found in Kitsai (Bucca and Lesser 1969: 18: n → h/__t, k, ?). But even if the phonetic facts in Old Norse were what Lightner claims, they would not constitute evidence for assimilation of nasals to vowels in the VNC → V:C process.

The most interesting evidence Lightner presents is from Lithuanian. Here is the relevant information:

1. Long and short vowels contrast.
2. Stressed short vowels are characterized by high pitch.
3. Diphthongs may have the structure VV, VL or VN (this is determined only by the way in which such combinations are affected by suprasegmentals; see 5 below).
4. Before j, v, l, r, m, n, s, z (=class Z), VN is realized as V: (Lightner assumes that nasalization has been eliminated by a further rule).
5. Diphthongs and long vowels have either rising or falling pitch. Kenstowicz (1969) has shown that is is possible to account for rising and falling pitch by supposing (1) that long vowels are underlyingly VV and (2) that one member of each underlying diphthong is marked for accent (high pitch). Consider, for example,

/brent+o/ -- brẽnto /brens+ti/ -- brẽ:sti

/brend+o/ -- brẽndo /brens+ti/ -- brẽ:sti

Notice that we apparently cannot write

$$V \rightarrow [+\text{nasal}] / __ N \begin{Bmatrix} \# \\ Z \end{Bmatrix} \qquad (1)$$

$$N \rightarrow \emptyset / \begin{bmatrix} V \\ +\text{nasal} \end{bmatrix} __ \qquad (2)$$

because the second rule would cause suprasegmental information to be lost when N is the element marked for stress. A preferable solution appears to be

$$V \rightarrow [+\text{nasal}] / __ N \begin{Bmatrix} \# \\ Z \end{Bmatrix} \qquad (1)$$

$$N \rightarrow V_i / V_i __ \qquad (2a)$$

The trouble is that, as Lightner himself points out in a different connection, there is 'presumably...a general split between segmental and suprasegmental phonology (1970: 187).' He therefore presumes himself that suprasegmentals need not be strictly aligned with segmental phenomena, in which case his own rule (2a)

would be ill-founded. Moreover, even if suprasegmentals do respect segmental constituents in this instance, it would be incautious to expand the assimilation solution to other languages on the basis of this evidence alone because it might be that the pressure to retain suprasegmental information in Lithuanian causes reinterpretation of nasal loss as an assimilation. On the other hand, we might simply entertain the possibility that suprasegmentals align themselves with underlying rather than surface representations which is equivalent to hypothesizing that a rule deleting a segment leaves its suprasegmental constituents intact in accordance with the idea that there is a split between segmental and suprasegmental phenomena.

I will also mention other criticisms of Lightner's treatment recently presented by Kenstowicz (1970: 103-8). He first questions Lightner's facilitating assumption that there is a vowel denasalization rule in Lithuanian, on the grounds that there is no vowel nasalization in the surface phonetic representation of Lithuanian words, and because Lightner's assumption is based only on poorly justified intuitions about universals. But, more importantly, he questions the assimilation solution itself:

> ...the validity of this analysis is far from obvious. Notice that the "assimilation" is complete, i.e. no property or feature of the original segment -the /n/- is retained, except for the accent. But it is reasonable to suppose that assimilation is of a continuous nature in which one segment becomes more and more similar to another to the limiting case of complete identity. Furthermore, it seems that clear cases of complete assimilation arise only when the two contiguous segments are already similar to begin with... Finally, it seems reasonable to assume that a hierarchy is involved in assimilation such that complete assimilation implies partial assimilation, but not vice versa...If these remarks are correct then the assimilation analysis for Lithuanian vowel-nasal sequences becomes rather suspect. Not only are there no properties of the dental nasal left behind, but it is rather difficult to imagine what such traces might be in a case such as this where the distance between /n/--a consonant--and a vowel is rather great, involving a transition across most of the feature properties--a fact which by itself casts suspicion on the analysis in the first place, given the few if any clear cases of <u>direct</u> conversion between consonants and vowels in language....Note that there is a much more straightforward analysis of the Lithuanian data in which only one rule is involved:

elision of the dental nasal /n/ with (compensatory) lengthening of the preceding vowel.

In Polish, nasalization occurs before word-final and precontinuant nasals. Nasals are lost before l. A problem arises here because nasal loss does not affect the preceding vowel. This is a difficulty for both the assimilation solution and one involving nasal loss, since both predict that the vowel will lengthen. But notice that the two solutions handle this problem in different ways. Lightner must claim that there is a process which simplifies the double vowel that results from assimilation; while in the case of the deletion solution, all that needs to be said is that vowel lengthening has been inhibited for some reason.

6.4. The componential treatment of nasal loss.

I will argue in favor of a fourth solution to the problem of nasal loss, one involving the independence of articulatory components (cf. Drachman 1969: 202-4). Notice that this solution involves compensatory lengthening, and, in a sense, deletion and assimilation as well, but that these three observed phenomena will now be viewed as concomitant effects of the migration of the oral closure component of the nasal toward the end of the word.

First consider three languages in which this notion of component migration seems essential:

(1) In Hausa (Hodge 1947: 10-1) final m and n may optionally be realized post-vocalically as nasalization of the vowel plus a "lightly pronounced" remnant of the nasal.

(2) In Keresan (Spencer 1946: 235) "among some speakers the final nasal consonant may be almost inaudible with a result that a heavily nasalized vowel is heard."

(3) In Brazilian Portuguese (Dahl 1961: 315-7) "some trace of the nasal consonant always persists" when vowels are nasalized by a following nasal.

Two comments are necessary. First notice the complementary relationship between vowel nasalization and the duration of oral closure in Hausa and Keresan. This is best handled as rightward migration of oral closure, while nasalization remains where it was. Next, reconsider vowel 'deletion' in Japanese in the light of these new examples. Notational conventions do not currently permit us to represent 'trace segments' as such; they must either be represented as full segments, or not given segment status at all. Also, the notion of compensatory lengthening is beyond the scope of rules as normally written when the lengthening is strictly complementary. Even with multivalued features it is impossible in principle, given the standard notation, to express the fact that one segment donates a specific but infinitely variable portion of its duration to an adjacent segment.

Other phenomena can be most incitefully viewed if the independence of nasality and oral closure is recognized:

(1) In Kaikang (Henry 1948: 195-6) nasal consonants either disappear or become voiceless and denasalized (n → t etc.) before any voiceless segment. Rather than postulate devoicing and denasalization, this process can be described as migration of the nasality component toward the front of the word since, at least in the case of ŋ→k, Henry points out that the change is accompanied by the addition of nasalization to the vowel.

(2) In Maxikali (Gudschinsky, Popovich and Popovich 1970: 83-6) syllable-initially

$$n \rightarrow \begin{Bmatrix} nd \\ d \end{Bmatrix} \; /__V \quad (V=\text{oral})$$

This is best described by saying that the velic component of the nasal retreats toward word-initial position.

In the same language, in syllable coda

$$n \rightarrow nt \; /__C \; (C=\text{non-homorganic})$$

which can be handled the same way. Also

$$p \rightarrow b^m \; /__.m \quad (\text{optional})$$

which can be viewed again as regressive migration of nasalization.

Without recognizing the tendency for the nasality component of Maxikali nasals to migrate 'leftward', we have no way of capturing the essential identity of these three phenomena.

(3) In the Dakota dialect studied by Matthews (1955: 59)

$$\tilde{V} \rightarrow V \; /__ \text{ nasal allophone of b, t, k}$$

To describe this phenomenon without componential migration we require two ordered rules:

$$C \rightarrow [+\text{nasal}] \; / \; \begin{bmatrix} V \\ +\text{nasal} \end{bmatrix} __ \qquad (1)$$

$$V \rightarrow [-\text{nasal}] \; / \; __ \; \begin{bmatrix} C \\ +\text{nasal} \end{bmatrix} \qquad (2)$$

(Note: vowel nasalization does not occur before true nasals!) We can eliminate both the necessity for a strange dissimilation rule[13] (2) and rule ordering by positing componential migration.

Finally, I will evaluate this proposal in the light of recently published work by Henning Andersen. He claims that in Polish a diachronic correspondence ṼC---VNC was implemented by means of three phonetic processes:

(1) nasality contracts to the latter half of the vowel;

(2) the nasalized portion of the vowel changes to a nasalized glide;

(3) the nasalized glide changes to a nasal consonant. The evidence for this is the existence of intermediate stages corresponding to each point of this progression. Andersen remarks that the first of these processes "consists in a gradually increasing delay in the onset of nasal resonance." Thus, he proposes component migration to handle at least one of the processes, and the question that immediately arises is whether the correspondence VNC--$\tilde{V}$:C discussed above, which is essentially the reverse of that considered by Andersen, can be handled in the same way, but with the order of application of the processes reversed. This may be so, although the glide stage is rarely attested, and the change in the domain of nasalization probably occurs first whether the correspondence is VNC--$\tilde{V}$:C or $\tilde{V}$C--VNC. In any case, it should be noted that Andersen does not specify exactly how consonantality of the final stage is achieved, and migration of oral closure is quite compatible with his treatment.

7. Summary[14]

(1) Regressive nasalization

(a) Regressive nasalization is most likely to occur before word-final nasals, is less likely before nasals followed by continuants, even less likely before nasals followed by non-continuants, and is most inhibited before nasals preceding vowels. These four post-nasal conditioning factors are arranged in a strict hierarchy such that those later in the foregoing list imply those earlier on. The post-nasal hierarchy can be explained by referring to sluggishness of the velum as an articulator (Bjork 1961), the requirement that the velum be raised in time to enable the pressure and airflow needs of post-nasal consonants to be met, and the tendency for vowels to be nasalized only by nasals in the same syllable.

(b) Vowels which undergo regressive nasalization are optimally low, back, and stressed.

(2) Progressive nasalization

(a) Languages may have both progressive and regressive nasalization.

(b) Post-nasal neutralization of distinctive nasalization is generally observed in languages with progressive nasalization.

(c) It is necessary to recognize two vowel hierarchies for progressive (and possibly also regressive) nasalization--one based on anatomical pressures (connection of the palato-glossus muscles and the musculature of the velum) and the other based on speaker-controlled immobility of the velum.

(3) Spreading nasalization

Nasalization does not spread from an initiating segment through a segment whose airflow or oral pressure

requirements are so high that the velum is forced shut. The set of segments permitting penetration by nasalization in particular languages is observed to vary slightly.

(4) Vowel shifts

If a nasalized vowel undergoes a change in quality not affecting oral vowels, that change is far more likely to result in backing than fronting of the vowel. Vowels undergoing contextual nasalization near nasals strongly tend to be raised rather than lowered. Vowels tend to be lowered if nasalization is accompanied by nasal loss.

(5) Nasal loss and nasalization

When, as is most frequently the case, nasals are lost to the left (rather than by assimilation to a following consonant producing gemination), they are lost through migration of the oral closure component of the nasal toward the following (almost invariably homorganic) consonant or word boundary, leaving the nasalization behind on the vowel as an information-bearing component. Compensatory lengthening of the vowel is an automatic feature of this solution.

Footnotes

1. I offer my sincerest thanks to Professor Gaberell Drachman, my adviser, for providing extensive criticism during the last few months and for reading each version of this paper. I am also grateful to Professors Arnold M. Zwicky and David L. Stampe for comments on early drafts, and to other faculty members and my fellow students in the Department of Linguistics for calling my attention to interesting data.

2. Ferguson mentions a single counterexample to this putative universal: in Iroquoian "one of the nasalized vowels posited for the protolanguage seems, on considerations of internal reconstruction, to have derived from earlier /a/ + /i/ or sequences like /awa/" (1963: 59). But beyond this, Bengali has at least one nasalized vowel which derived from a Vr sequence: sãp<sarp, 'snake,' cf. Sanskrit sṛp. In Spanish of rural Panama (Robe 1960: 36) nasalized vowels appear in alternation with Vr and Vl sequences in absolute final position:

bamohaβ̞ér	or	bamohβ̞ẽ́	'vamos a ver'
bamohasé̞r	or	bamohasẽ́	'vamos a ser'
bwènomuxé̞r	or	bwenomuxẽ́	'bueno mujer'
myé̞l	or	myẽ́	'miel'

àniməl or ànimə́ 'animal'

In Sanskrit (Allen 1961: 39-46) nasalization of vowels is a feature of finality of the sentence or breath group. As mentioned earlier, vowels are nasalized following word-boundary and h as well as after nasals in Thai.

3. Arnold M. Zwicky (1972) claims that the following hierarchy occurs repeatedly in rules of English:

Vowels glides r l n m ŋ fricative stop

and points out that in Ịjọ w, r, y and vowels are penetrated by nasalization, but l is not (see section 3 above). Although the hierarchy established above for regressive nasalization is not as detailed as this one, the correspondences are nevertheless quite striking.

4. On the basis of eight languages in the foregoing list (see asterisks), Theodore Lightner (1970) has attempted to formulate a universal rule for regressive vowel nasalization. He found the necessary formulation extremely complicated and had to abandon it in favor of a general tendency for languages to contain a rule of this form:

$$V \text{--} [+\text{nasal}] \;/\; __ N \left\{ \begin{matrix} \# \\ C \end{matrix} \right\} \text{ (where V and N not separated by } \emptyset)$$

This formula was suggested three years earlier by Milner (1967: 280) as a marking convention:

$$[\alpha \text{ nasal}] \text{ --- } [+\text{nasal}] \;/ \left[\begin{matrix} V \\ ___ \end{matrix} \right] N \left\{ \left[\begin{matrix} C \\ [-\text{seg}] \\ . \\ . \\ . \end{matrix} \right] \right\}$$

In view of the evidence presented above, it is at least clear that Lightner's 'tendency' must be considerably more detailed.

5. Consider, for example, Saciuk's remark (1970: 204) on Portuguese: "Very accurate measurements with mechanical devices indicate some nasalization in vowels preceded by N, but the degree of nasalization in this case is weaker than in the vowels that undergo the rules of nasalization, progressive nasalization, or secondary nasalization."

6. In a lecture presented at the Ohio State University on April 4, 1972.

7. In forms with a plural infix al/ar after a root-initial nasal consonant, nasalization is observed not only in the first vowel of the infix, but also in the second vowel following the infix (Robins 1957: 93):

mīāk---māriāk 'to stand aside'

Compare the following form which has no infix:

mãrios 'to examine'

This situation, confirmed by kymography, seems best handled by a cyclic nasalization rule and a post-obstruent denasalization rule. On the first cycle, the unaffixed form is nasalized (miak---mĩãk); then the infix is added and the rule applies again (--mãrĩãk); finally, the vowel is denasalized after the obstruent. The weakness of this solution is that it is only observationally adequate. The generalization that needs to be captured is that the affixed form is 'double' in that it presents itself simultaneously to the nasalization rule both as itself and an unaffixed form.

8. This wording is meant to exclude prosodic nasalization as is found in Desano (Kaye 1971) and Gbeya (Samarin 1966: 29).

9. Some discussion is necessary here. Gibson has neglected to say exactly what it means for nasalization to spread "to the end of the word." I have taken her to be referring only to vowels, and this is reflected in my transcription of her examples (in her article Gibson only marks the phonemically nasalized vowel). I presume that if she had meant for the reader to believe that Pame has nasalized voiceless tops (whatever that might mean), she would have commented on it separately.

10. Drachman and Drachman (1971) point out that there are at least two, and possibly three ways to "dispose" of a nasal in VNC sequences; the length can be given to the preceding vowel as in the examples discussed in this section, or it may be given to the consonant (via gemination) resulting in V:C and VC: respectively. If a language permitted neither vowel length nor gemination of consonants, it might simply delete the nasal, but no cases have turned up yet.

11. This is not quite true. Clusters can arise morphologically as well (McCawley 1968).

12. In Sanskrit, to cite another example, "if through morphological processes rr would occur, it never does--instead the preceding vowel is made long, if it is not already "long"" (Allen 1962: 179). Cf. also Sanskrit

taḍdhi → ta:ḍhi

dus+dabha → du:dabha etc.

13. In Picuris there is what appears to be dissimilation of nasality, but unlike in the (false) Dakota example, it is incomplete. Distinctively nasalized vowels are most nasalized when not before nasals. After a nasal consonant, a nasal vowel is less nasalized at the beginning than at the end; before a nasal consonant a nasal vowel is more nasalized at the beginning than at the end. The environment in which nasalization is most diminished is the environment which, in other languages, is most likely to induce nasalization. (Consider, for example, Saciuk's remark (1970: 205); "The highest degree of nasality would appear in vowels that occur between two nasal

consonants in the phonetic representation." Robe (1960: 36) says that in Panama Spanish, although vowels are only sporadically nasalized in other environments, they regularly receive slight nasalization between two nasals. Navarro (1963: 39; cit. by Saciuk 1970) claims that Spanish exhibits completely nasalized vowels in this environment. In Pame (Gibson 1956: 258) slight non-contrastive nasalization occurs only between two nasals in a closed syllable.) Since there is apparently no reason for speakers of Picuris to try to denasalize distinctively nasalized vowels, some other account is preferable. Probably there is no disimilation at all, but instead the interaction of two kinds of nasalization of the kinds Delattre has shown exist in French (sec. 5). The 'disimilations' in Picuris could then be regarded as artifacts of the switch-over from (to) ordinary velum lowering (which, Delattre has shown, is used for nasal consonants) to (from) equalization of the volumes of the oral and nasal pharynges. This speculation should be seriously considered if the degree of nasality to which distinctively nasalized vowels are reduced when adjacent to nasal consonants in Picuris can be experimentally shown to be equivalent to the degree of contextual nasalization of oral vowels.

14. Because of delays, this paper is being published after a subsequently delivered LSA paper which clarifies and revises several of the claims made here. The two most important revisions are the establishment of a regular hierarchy governing penetration of nasalization, and the disentanglement of cases of nasal loss (with concomitant vowel nasalization) from cases of vowel nasalization proper.

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